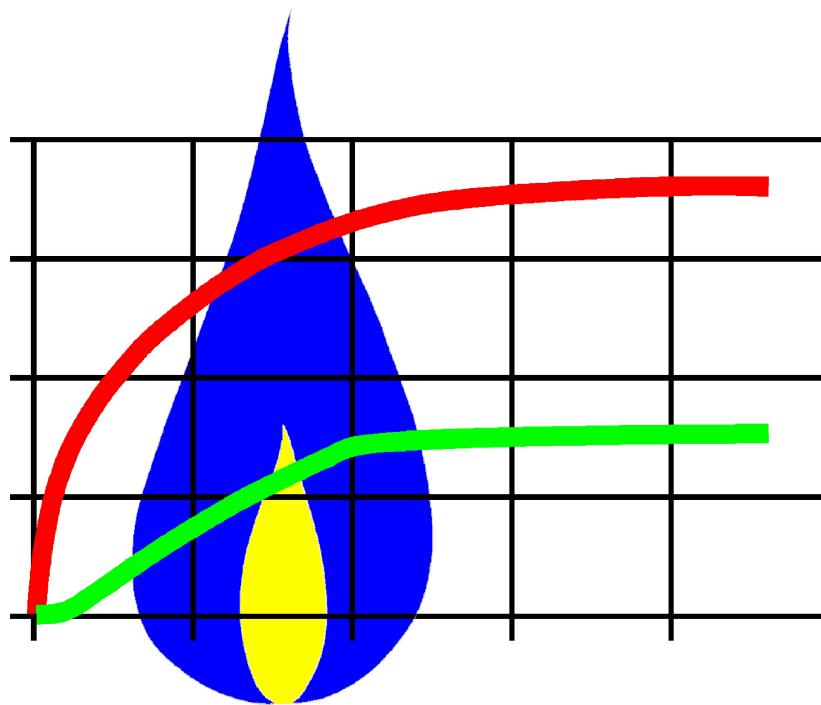


GAS PurgeTM

User's Guide



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The GASPurge service is also known as the GASPurge Hydraulic Calculator.

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INTRODUCTION

Purpose of This Document

It is assumed that the User of GASPurge (the “Service”) has a proficient understanding of pipeline purging theory and practice. The purpose of this document is to provide information on the use of the Service. This document is *not* intended to provide the background information necessary to purge a pipeline. The reader is encouraged to refer to the latest version of the American Gas Association’s Purging Manual (the “Purging Manual”) for guidance on general purging theory, practices, and methods.

Purpose of GASPurge

Pipelines are commonly purged to remove the gas content or to replace it with another gas. When properly controlled, the purge operation causes the injected gas to displace the current pipeline contents with minimum gas mixing at the interface of the two gases. It is especially important to minimize this gas mixing when flammable mixtures are formed near the interface between the Purge Gas and the Pipeline Gas. Less mixing or dilution generally means more efficient purging.

GASPurge can be used to assist in planning a pipeline purge. The Service is used to estimate the purge time, purge pressure, gas flow rate, and the required inert gas volume for a User-specified pipe geometry.

Note...

In practice, the process of removing air from a pipeline by introducing natural gas is commonly referred to as “purging”. The process of removing natural gas from a pipeline by introducing air or another gas is commonly referred to as “clearing”. For this document, the terms “purge” and “purging” are used interchangeably to represent both processes. The process being performed is identified by indicating the *Pipeline* and *Purge* gas types.

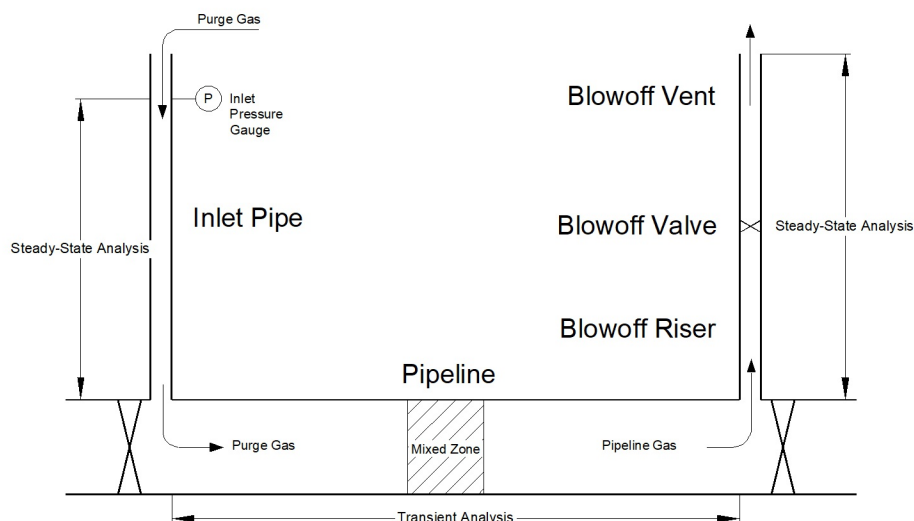
Pipeline Purge Model

The Service utilizes three components to model the process of purging a pipeline - an Inlet Pipe, a Pipeline, and a Blowoff Assembly (see Figure 1). These components are used to calculate:

- The pressure drop and flow rate so that the purge time can be determined.
- The minimum purge velocity needed to ensure that the flow is not stratified.
- The length of the mixed gas region that forms at the interface between the Purge Gas and Pipeline Gas (this is used to determine the amount of inert gas needed to keep flammable gases separated in the Pipeline).

A brief description of each calculated data value is provided in the following sections.

Figure 1 - Identification of calculation methods.



Pressure Drop, Flow Rate, and Purge Time

To estimate the time required to complete a purge, the flow rate and pressure drop through the piping must be determined. The Colebrook-White pipe flow equation is used to model the relationship between the flow and pressure drop in the Inlet Pipe, Pipeline, and Blowoff Assembly. The Inlet Pipe and Blowoff Assembly are modeled using a steady-state analysis. The Pipeline is modeled using a transient analysis.

A time-dependent (transient) model is used to more accurately simulate the pipeline purge operation. It is assumed that the Blowoff Valve is opened just before the start of the purge operation. This allows the assumption that the initial pressure in the pipeline is at or near atmospheric pressure. Once the Purge Gas starts to flow into the Pipeline, the pressure in the Pipeline starts to rise. The gas already in the Pipeline is compressed, and the amount of gas stored in the pipeline increases. Steady-state modeling of this process would not accurately account for these changing conditions.

Depending on the pressure and flow rate, it may be possible for the flow velocity to reach sonic velocity in portions of the "system". When this occurs, the flow is referred to as "choked". Similar to "critical" flow through a regulator, the pipe flow rate cannot increase beyond the choked flow value without an increase in the inlet pressure. The most likely locations for choked flow to occur are at the outlet end of the Inlet Pipe or at any location along the Blowoff Assembly. The model incorporates checks to determine if choked flow has occurred at these locations and handles the resulting pressure and flows accordingly.

Stratification and Minimum Purge Velocity

During a purge, the gas velocity in the Pipeline must be kept high enough to avoid stratification of the gas in the Pipeline. At lower gas velocities, the lighter gas can flow over the top of the heavier gas; this is referred to as stratification. Stratification can create sections of pipe with a combustible gas mixture, which can result in an incomplete purge; both of these conditions should be avoided.

Two criteria are checked to determine the minimum allowable purge velocity. The first criterion is to require turbulent flow in the Pipeline at the gas-to-gas interface, which minimizes gas mixing. The second criterion requires that the purge velocity exceeds the velocity at which stratified flow can occur. Once both of these criteria are checked, the higher of the two velocities is reported as the minimum purge velocity.

Refer to the Purging Manual for a detailed discussion of stratification and required minimum purge velocities.

Mixing of the Purge Gases and Inert Slug Volume

It is desirable to minimize the amount of mixing of air and any combustible gases during a purge. However, there is little that can be done to reduce the mixing as the gases flow along the Pipeline. The longer the Pipeline, the larger the mixed gas region. An inert gas can be used to separate air and a combustible gas, preventing the creation of a flammable gas mixture. The rate of gas mixing in the Pipeline must be calculated to determine the volume of inert gas needed to separate the Purge Gas and Pipeline Gas.

When the Purge Gas and Pipeline Gas are composed of a combustible gas and air, the length of the mixed gas region is calculated at the Pipeline end pressure. The volume of inert gas needed to separate the combustible gas from the air can then be determined. The method used to calculate the mixed gas length is similar to that described by the Purging Manual. See the Purging Manual for a detailed discussion of the Mixed Zone.

For the mix zone calculation, it is assumed that the mixing (diffusion) behavior of the hydrogen-blended gas types is similar to the mixing behavior of a typical natural gas composition.

OPERATION

System Requirements

The Service will operate on any device with internet access.

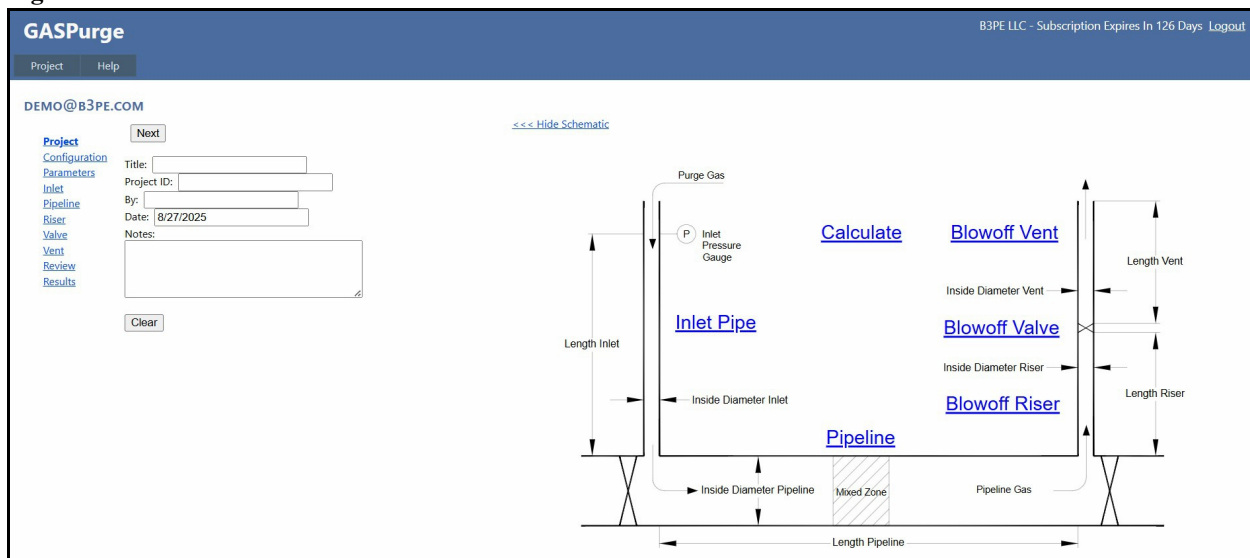
Installation

Local installation of the Service is not required. The operating portions of the Service are installed and operate on a remote server. The Service is accessed through a browser on the local machine or device.

Interface

The interface for the Service consists of a simple menu, a calculation wizard (the “Wizard”), and a system schematic (the “Schematic”). The Wizard consists of several steps, which, when completed, will allow the calculation to be performed and the results to be displayed. Although the Wizard provides a step-by-step process for entering the required data, any step can be completed in any order, and the results can be calculated as long as valid data is entered for each required data value. See Figure 2 for an example image of the GASPurge interface.

Figure 2



Launching The Service

Note - It is assumed that a subscription to the Service has already been purchased.

- On an internet-connected device, open a browser of your choice.
- Navigate to the following address: <https://www.b3peapp.com>
- Click the link to the GASPurge application.
- The Login page and main GASPurge window will appear.
 - If this is your first time using the Service, you will need to register as a User. Click the “Register a new email address” link on the main GASPurge window to navigate to the Registration page.
 - On the Registration page, enter a valid email address and the provided B3PE Customer ID into the appropriate data fields. Click the *View End User License Agreement* link. Then click the checkbox to accept the “EULA”. Click the *Continue* command button when finished to register your account and return to the Login page.
- Once you have a registered account, enter the email address associated with your account into the *Email Address* data field.
- Click the *Continue* command button.

Note...

The Service is provided on a subscription basis, intended as one subscription per User. The number of Users allowed to concurrently access the Service using the same Customer ID cannot exceed the number of subscriptions associated with the Customer ID. At the time of login, if there are no unused subscriptions available for the Customer ID associated with your registered email address, you will not be able to log in.

Navigation

The Wizard lists and displays the “steps” required to enter the data needed to complete a calculation. The Wizard contains several links and command buttons for navigating forward and backward through the steps. Most steps have a *Next* command button for navigating to the next step in the Wizard, and a *Previous* command button for navigating to the prior step, with the following exceptions:

- The Project step features only the *Next* command button.

- The Review step features the *Previous* command button. The *Next* command button is replaced by the *Calculate* command button. Clicking on this button will calculate the purge results of the entered data and navigate to the Results step.
- The Results step features only the *Previous* command button.

The “sidebar” contains links to the various steps associated with the Wizard. Clicking on one of these links will display the step named by the link. Clicking on the *Results* link recalculates the results (if a data change has occurred since the last calculation) and navigates to the Results step.

The Schematic contains links to various steps associated with the Wizard. Clicking on one of these links will display the step named by the link. The Schematic also has a *Calculate* link, which functions similarly to the *Calculate* command button on the Review step.

Note...

Do not use the browser’s *Back*, *Forward*, or *Refresh* buttons to navigate the Service. Doing so can result in unexpected behavior.

General Calculation Procedures

After logging in, the Project page will be displayed. The first time loading the Service with a new email address, the project data will be populated with a set of “default” data values. If logging in with a previously used email address, the project data will be populated with data from the last calculation performed using the login email address. To calculate the various values associated with the purging or clearing of a pipe segment, complete the following steps:

Note...

For first-time use, check the following settings:

- Select an appropriate “Zoom Scale” from the *Zoom* submenu of the *Project* menu. This will make the display more readable.
- Select the display of the System Schematic using the “Show Schematic” or “Hide Schematic” link.

- On the Project step, either enter new project details or edit the displayed values. Click the *Next* command button to move to the next page.
- On the Configuration page, enter or select data values for the Purge Gas and Pipeline Gas. Click the *Next* command button.
- On the Parameters step, enter or select appropriate values for the various parameter items. Click the *Next* command button.

- On the Inlet step, indicate whether an *Inlet Pipe* is present. If an Inlet Pipe is present, enter or select the appropriate data values and fittings. Click the *Next* command button.
- On the Pipeline step, enter or select appropriate values for the various pipeline items. Click the *Next* command button.
- On the Riser step, indicate whether a *Blowoff Riser* is present. If a Blowoff Riser is present, enter or select the appropriate data values and fittings. Click the *Next* command button.
- On the Valve step, indicate whether a *Blowoff Valve* is present. If a Blowoff Valve is present, enter or select the appropriate data values. Click the *Next* command button.
- On the Vent step, indicate whether a *Blowoff Vent* is present. If a Blowoff Vent is present, enter or select the appropriate data values and fittings. Click the *Next* command button.
- On the Review step, review the entered data values. Click the *Calculate* command button.
- On the Results step, view the calculation results. The results can be saved to a spreadsheet file format or printed.

Clear Data Values

Sometimes it is desirable to start with an “empty” set of data values, rather than changing each existing value to a new one. Click the *Clear* command button on the Project step to remove all data values (set to empty) for all steps, except the Configuration step.

Display Help Contents

This User’s Guide is stored in Portable Document Format (PDF) on the server. To access the guide, select *User’s Guide* from the *Help* menu. A compatible version of Adobe Acrobat Reader or an equivalent application must be installed to view the User’s Guide.

Display The Schematic

The Schematic provides a graphic depiction of the various data values required to perform a purge calculation. To display the schematic, select the *Show Schematic* link to the right of the Wizard. To hide the schematic, select the *Hide Schematic* link.

Note...

To keep the display screen from becoming cluttered on small devices, the Schematic can only be displayed if the Zoom Scale is set to “1.0”.

Open A Saved Calculation File

If the calculation input data was previously saved, the associated file can be opened, and the data used to populate the Wizard will be displayed. To open a previously saved Purge Project (calculation input data) file, select *Open* from the *Project* menu. The File Selection page will be displayed. Depending on the device, browser, and operating system, a command button similar to “Browse” will be displayed on the page. Click the *Browse* command button to open the system “file explorer”, and find and select the desired file. After the file has been selected, it should appear on the File Selection page. Click the *Continue* command button to retrieve the file contents.

Note...

- The calculation input data can be saved to a local file for future use. Selecting *Open* from the *Project* menu allows a previously saved input data file to be retrieved.
- Only calculation data saved to a file with a “.prg” extension can be opened.
- The location of the saved files is dependent on the device, browser, and operating system used to access the Service. In some cases, the file will be saved at a User-specified location, at a default browser/operating system location, or perhaps not at all.
- The appearance of the File Selection page and the system “file explorer” will vary depending on the device, browser, and operating system used.

Print The Data & Results

Both the calculation data and results can be printed by clicking the *Print* command button on the Results step. To print only the calculation (input) data, click the *Print* command button on the Review step. When the *Print* command button is clicked, a “Print Preview” page will be displayed. Click the *Print* command button on the Print Preview page. Depending on the device, browser, and operating system, additional prompts may appear to select print options and printer location. Click the *Close* command button to exit the Print Preview page.

Note...

The Print Preview page opens in a new window or tab. If a “pop-up blocker” is present, it may prevent the new window/tab from opening. Depending on the browser being used and the type of pop-up blocker, different settings may need to be configured to allow the Service to open new windows or tabs.

Save The Calculation Data

The calculation input data entered using the Wizard can be saved for future use or as the basis for another calculation. To save the data values, select *Save* from the *Project* menu list. Depending on the device, browser, and operating system, additional prompts may appear to select the file location or other options.

Note...

- The calculation input data can be saved to a local file for future use. When *Save* is selected from the *Project* menu, the calculation input data values are saved.
- The calculation data is saved to a file with a “.prg” extension. Do not change this extension, as the saved file will become unusable.
- The location of the saved file is dependent on the device, browser, and operating system used to access the Service. In some cases, the file will be saved at a User-specified location, at a default browser/operating system location, or perhaps not at all.

Save The Calculation Results

The data points used to create the graphical results can be saved for use in other applications, providing opportunities for further analysis or presentation. When saved, the values are stored in either a comma-separated values (.csv) file or in a Microsoft Excel format (.xlsx) file. Either of which can be opened by most spreadsheet applications.

To save the calculation results, click the *Save Results* command button on the Results step. Depending on the device, browser, and operating system, additional prompts may appear to select the file location or other options.

Note...

See the *Notes & Considerations* section of the Results step description for a list of the file contents.

View/Edit The Fitting Equivalent Length Values

The pressure drop associated with fittings installed along any of the piping segments is calculated using equivalent length values. Equivalent length values are expressed as an Le/D value for a generic fitting type (for example, elbow, tee, valve). A “default” set of Le/D values is provided. These values can be changed by the User if you prefer your own or alternative values. To view or edit the current Le/D values, select *Fittings* from the *Project* menu; the Fittings page will be displayed. Make desired changes or click the *Reset* command button to restore the original default values. Click the *Apply* command button to save the currently displayed values.

Note...

See the *Notes & Considerations* section for the Fittings page description for additional information.

Zoom Page Display

Depending on the device used to access the Service, it may be desirable to adjust the size of the Service pages. To change the page display size, select the desired zoom scale from the *Zoom* submenu of the *Project* menu.

Note...

The Zoom Scale is saved in a User configuration file and is persistent until changed by the User. It may be necessary to adjust the scale when changing between devices or operating systems.

Log Out Of The Service

To log out of the Service, select the *Logout* link in the upper-right corner of the main GASPurge window.

PAGE DESCRIPTIONS

The content and functionality of the various web pages and Wizard steps used by the Service are described in the following sections. The pages and steps are listed in alphabetical order by page or step name.

Note...

- The example screenshots shown in the following sections were taken using a Google Chrome browser, operating on a Windows 10 computer. The appearance of some features, such as command button labels, may vary depending on the device, browser, and operating system being used to access the Service.
- Data fields with a yellow colored background display calculated values. Data fields and lists with a white colored background represent values that need to be entered or selected.

Configuration Step

The Configuration step is used to indicate the properties of the Purge Gas and Pipeline Gas. To access the Configuration step, select the *Configuration* link from the Sidebar. The features associated with the Configuration step are described as follows.

The screenshot displays the 'Configuration' step interface. On the left is a sidebar with links: Project, Configuration (highlighted), Parameters, Inlet, Pipeline, Riser, Valve, Vent, Review, and Results. At the top right are 'Previous' and 'Next' buttons. The main area is divided into two sections: 'Purge Gas' and 'Pipeline Gas'. Each section has a dropdown menu for gas type, input fields for 'Specific Gravity' and 'Viscosity', and a unit selector for viscosity. In the 'Purge Gas' section, 'Typical US Natural Gas' is selected, 'Specific Gravity' is 0.567, and 'Viscosity' is 0.000007 Lbm/Ft-Sec. In the 'Pipeline Gas' section, 'Air' is selected, 'Specific Gravity' is 1.000, and 'Viscosity' is 0.000012 Lbm/Ft-Sec.

Data Items

Pipeline Gas - Indicates the initial content of the Pipeline. The gas that is to be vented from the Pipeline is called the Pipeline Gas (the gas present in the Pipeline at the start of the purge).

Specific Gravity - Specifies the specific gravity value of the gas initially contained in the Pipeline. This data field is only enabled if “Other - Entered Values” is selected for *Pipeline Gas*. The value is dimensionless.

Viscosity - Specifies the dynamic (absolute) viscosity of the gas initially contained in the Pipeline. This data field is only enabled if “Other - Entered Values” is selected for the *Pipeline Gas*.

Purge Gas - Indicates the type of gas being used to purge or clear the Pipeline Gas. The gas that is being injected into the Pipeline is called the Purge Gas.

Specific Gravity - Specifies the specific gravity value of the gas being used to purge or clear the Pipeline. This data field is only enabled if “Other - Entered Values” is selected for the *Purge Gas*. The value is dimensionless.

Viscosity - Specifies the dynamic (absolute) viscosity of the gas being used to purge or clear the Pipeline. This data field is only enabled if “Other - Entered Values” is selected for the *Purge Gas*.

Command Buttons

Next - Navigates through the Wizard Steps. Clicking this command button will display the next step in the Wizard.

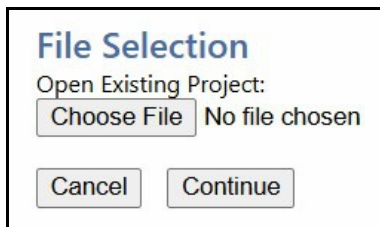
Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Notes & Considerations

- The *Specific Gravity* value represents the ratio of the weight of the associated gas to dry air. The specific gravity of dry air is 1.0.
- The Pipeline Gas represents the gas initially contained in the Pipeline.
- The Purge Gas represents the gas being injected into the Pipeline.
- The properties for the “Typical US Natural Gas” gas type and the hydrogen blends are based on an “average” composition as identified in Reference 10. See the *Background Information* section for additional information. Select the “Other - Entered Values” gas type to enter alternative property values.

File Selection Page

The File Selection page is used to specify the name of a Purge Project (calculation input data) file to open. To access the File Selection page, select *Open* from the *Project* menu. The features associated with the File Selection page are described as follows.



Command Buttons

Cancel - Exits the page without opening a previously saved Purge Project file.

Choose File - Used to select a previously saved Purge Project file. When selected, the system “file explorer” will be displayed. Find and select the desired file name, then click the appropriate command button to save the selection.

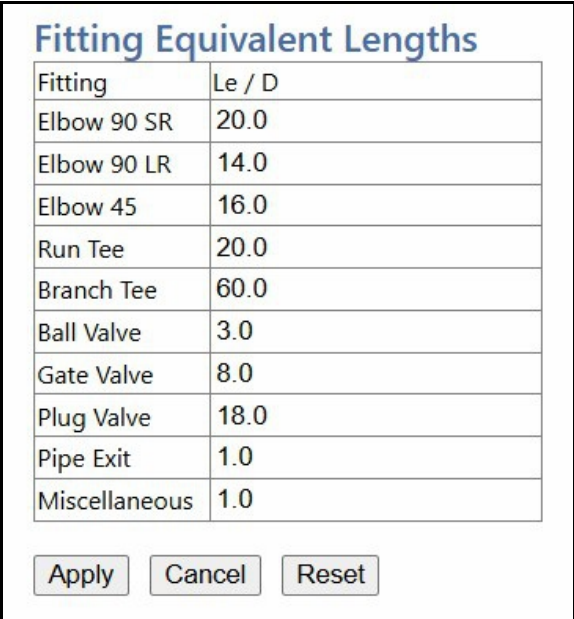
Continue - Retrieves the calculation input data values from a previously saved Purge Project file.

Notes & Considerations

- The term “file explorer” is used to refer to the system function, application, or utility that allows an existing file to be found and selected.
- Not all devices, browsers, or operating systems will allow a Project file to be saved or retrieved.
- The label on the “Choose File” button may vary depending on the device, browser, and operating system being used to access the Service.

Fittings Page

The Fittings page is used to specify the equivalent length ratio (Le/D) associated with the various fittings that can be assigned to a pipe segment. To access the Fittings page, select *Fittings* from the *Project* menu, or click the *Fitting Equivalent Lengths* command button on the Parameters step. The features associated with the Fittings page are described as follows.



Fitting	Le / D
Elbow 90 SR	20.0
Elbow 90 LR	14.0
Elbow 45	16.0
Run Tee	20.0
Branch Tee	60.0
Ball Valve	3.0
Gate Valve	8.0
Plug Valve	18.0
Pipe Exit	1.0
Miscellaneous	1.0

Apply Cancel Reset

Data Items

Fitting Equivalent Lengths - Displays a table of Le/D values associated with the adjacent Fitting type.

Command Buttons

Apply - Closes the page, saves, and applies the displayed Le/D values.

Cancel - Closes the page without saving the displayed Le/D values.

Reset - Resets the fitting values to the original “default” values.

Notes & Considerations

- Pressure drop across fittings attached to a pipe segment is calculated using an equivalent length value. For a specific fitting, the equivalent length is calculated by multiplying the Inside Diameter (in feet) of the associated fitting by the Le/D for the fitting. Reference 2 provides a good source for these values.

- If a fitting is assigned to a pipe segment, its current Le/D value is listed when the review or results are printed.
- If a Blowoff Vent is included, the equivalent length of a “pipe exit” is added to the hydraulic length of the vent.
- When a fitting is assigned to a pipe segment, it is assumed to have the same Inside Diameter as the segment that it is assigned to. For example, a fitting assigned to the Inlet Pipe is assumed to have the specified *Inside Diameter* value as its Inside Diameter.
- The Fitting lists on the various steps are used to input the number and type of fittings located in the Inlet and Blowoff Assembly. The fittings are included in the description of the pipe geometry to account for their additional pressure drop.
- It is not appropriate to use the equivalent length method in the transient analysis used for the pipeline component. Therefore, fittings are not allowed to be attached to the Pipeline.
- When working with valves, the valve’s Cv value can be converted to a Le/D value using the following equation:

$$\left(\frac{Le}{D}\right)_{valve} = \frac{1}{f_t} \left(\frac{29.9 \times d^2}{Cv}\right)^2$$

Where,

f_t = Fully Turbulent Friction Factor, 0.015

d = Effective Valve Diameter, Inches

Cv = Valve Flow Coefficient, gpm / 1psi pressure drop

Inlet Step

The Inlet step is used to indicate whether an Inlet Pipe is present and, so, to specify its properties. To access the Inlet step, select the *Inlet* link from the Sidebar. The features associated with the Inlet step are described as follows.

[Project](#)
[Configuration](#)
[Parameters](#)
[Inlet](#)
[Pipeline](#)
[Riser](#)
[Valve](#)
[Vent](#)
[Review](#)
[Results](#)

PreviousNext

Inlet Pipe:
☒ Yes ☐ No

Inside Diameter:

Select

Inches

Wall Roughness: Inches

Length: Feet

Hydraulic Efficiency:

Inlet Fittings:

Fitting	Quantity
Elbow 90 SR	<div>0</div>
Elbow 90 LR	<div>0</div>
Elbow 45	<div>0</div>
Run Tee	<div>0</div>
Branch Tee	<div>0</div>
Ball Valve	<div>0</div>
Gate Valve	<div>0</div>
Plug Valve	<div>0</div>
Miscellaneous	<div>0</div>

Reset

Data Items

Hydraulic Efficiency - Specifies the hydraulic efficiency of the Inlet Pipe. The value is expressed as a “factor” (for example, enter 0.5 for 50%).

Inlet Fittings - Indicates the number and type of fittings attached to the Inlet Pipe.

Inlet Pipe - Indicates whether or not an Inlet Pipe is present. If no Inlet Pipe is used, the other data values will be ignored.

Inside Diameter - Specifies the inside diameter of the Inlet Pipe.

Length - Specifies the hydraulic length of the Inlet Pipe. This is the distance between where the inlet pressure is being measured and the connection to the Pipeline.

Wall Roughness - Specifies the effective pipe wall roughness of the Inlet Pipe.

Command Buttons

Next - Navigates through the Wizard Steps. Clicking this command button will display the page associated with the next step.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

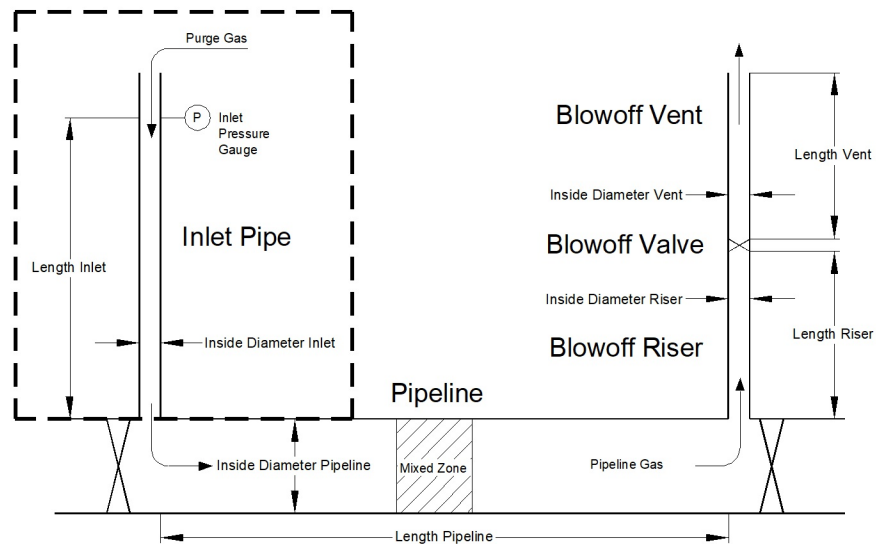
Reset - Clears the *Inlet Fittings* lists.

Select - Displays the Pipe Selection page. Use the various data lists on the page to specify a value, then click the *Apply* command button to assign the displayed value and return to the Inlet step.

Notes & Considerations

- The hydraulic efficiency is used to adjust or tune the performance of the pipe flow equation to better match actual field results. For the Inlet Pipe, the value should normally be between 0.5 and 0.7.
- Fittings attached to the Inlet Pipe are assumed to have the same Inside Diameter as the specified *Inside Diameter* value.
- The pressure drop associated with the assigned fittings is calculated using an equivalent hydraulic length value. The associated equivalent length value is calculated based on the assigned Le/D value. The default Le/D values can be revised using the Fittings page.
- If no Inlet Pipe is indicated, the Purge Gas is assumed to be introduced directly into the upstream (inlet) end of the Pipeline. For example, when the Purge Gas is being introduced through a “line” or “block” valve immediately upstream and connected to the Pipeline.

Figure 3 - Inlet Pipe Component.



- The effective pipe wall roughness of the inside surface of the Inlet Pipe is used to calculate the friction factor value used in the pipe flow equation. The value of wall roughness varies depending on the pipe material, service conditions, and pipe age. Some examples are given in Table 1. References 2 and 3 present older values of wall roughness for different types of pipe. Reference 9 presents more modern values of wall roughness for steel and plastic pipe.

Table 1 - Example Pipe Roughness Values		
Type of Pipe	Condition of Pipe	Effective Roughness (Inches)
Steel (Vintage value)	New and Clean	0.0018 ①
Steel (Modern value)	New and Clean	0.0007 ②
Steel	Light Rust	0.0096 ①
Cast Iron	New and Clean	0.0102 ①
Galvanized Iron	New and Clean	0.0060 ①
Polyethylene Plastic	New and Clean	0.00006 ②
① Reference 5		
② Reference 9		

Login Page

The Login page is used to log into the Service. The page will be displayed whenever the Service is accessed by your browser. The Login page can also be accessed by selecting the *Login* link in the upper-right corner of the window. The features associated with the Login page are described as follows.



Data Items

Email Address - Specifies the email address that will be used to identify the User. Enter a valid email address that is associated with your registered User Account.

Command Buttons

Continue - Logs into the Service using the specified Email Address and proceeds to the Project page.

Links

Or click here... - Navigates to the Registration page. Click this link if you have not registered a User Account or would like to register a new User Account.

Notes & Considerations

- Access to the Service is restricted to Users with valid subscriptions.

- Failed attempts to log into the Service will result in an error message being displayed. The following is a list of error messages that may appear:

Account Override - The current User Account has logged into the Service from a new browser.

Email Not Registered - The entered email address has not been registered as a valid User Account. Email addresses can be registered from the Registration page.

Login Required - An attempt was made to access one of the Service pages without proper credentials.

Required Field - The *Email Address* field is blank.

Session Timed Out - The User Account has been logged out due to extended inactivity.

Subscription Expired - The Customer ID associated with the User Account does not have an active subscription to the Service.

User Limit Reached - The Customer ID associated with the User Account has reached the maximum number of logged-in Users allowed by its subscription.

Unable To Locate License File - The Service could not read the license file associated with the User Account. Closing the current browser window and then reopening the Service in a new browser window typically resolves this issue.

- When a User is logged in, a *Logout* link will appear in the upper-right corner of the main GASPurge window. Selecting this link will log the User out and navigate to the Login page.

Parameters Step

The Parameters step is used to set various parameters associated with the purge process. To access the Parameters step, select the *Parameters* link from the Sidebar. The features associated with the Parameters step are described as follows.

Project
Configuration
Parameters
Inlet
Pipeline
Riser
Valve
Vent
Review
Results

Previous Next

Control Variable:
☒ Pressure ☐ Flow

Inlet Pressure: Psig ▼

Base Pressure: Psia ▼

Base Temperature: Fahrenheit ▼

Local Atmospheric Pressure: Psia ▼

Plot Time Interval: Seconds ▼

Maximum Time Duration: Minutes ▼

Fitting Equivalent Lengths

Data Items

Base Pressure - Specifies the value of the pressure basis for the “standard” volume and volumetric flow values used and reported by the Service.

Base Temperature - Specifies the value of the temperature basis for the “Standard” volume and volumetric flow values used and calculated by the Service.

Control Variable - Indicates whether the purge is flow-controlled or pressure-controlled.

Inlet Flow Rate - Specifies the controlled flow rate. Enter a value by typing it into the data field. This item is only displayed if “Flow” is selected for the *Control Variable*.

Inlet Pressure - Specifies the controlled pressure value. This item is only displayed if “Pressure” is selected for the *Control Variable*.

Local Atmospheric Pressure - Specifies the atmospheric pressure value to be used during the calculation.

Maximum Time Duration - Specifies the maximum elapsed “purge” time allowed for the calculation.

Plot Time Interval - Specifies the time interval for recording the incremental pressure and flow values displayed or reported in the calculation results.

Command Buttons

Fitting Equivalent Lengths - Displays the Fittings page.

Next - Navigates through the Wizard Steps. Clicking this command button will display the next step.

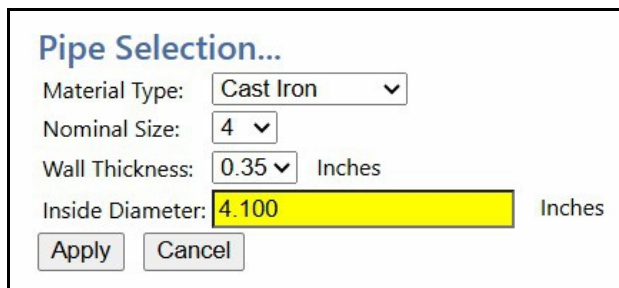
Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Notes & Considerations

- The “Control Variable” identifies the type of control of the inlet flow used during the purge process. It is assumed that whichever control method is used, the controlled value can be consistently maintained throughout the purge process.
- The label and units list associated with the Control Variable change depending on the selected *Control Variable* option. However, the value in the data field only changes if the User enters a new value. When toggling the *Control Variable* option between “Pressure” and “Flow”, take care to ensure that the entered value and the associated dimensional units are correct for the specified Control Variable. Failure to do so will yield unexpected results.
- The Base Pressure and Base Temperature are used to establish the basis of a “standard” volume of gas. For example, to establish the basis of a standard cubic foot of gas. In the United States, a value of 14.73 Psia is typically used for the Base Pressure, and 60 Fahrenheit for the Base Temperature.
- The Local Atmospheric Pressure is used to convert gauge pressure values to absolute pressure values during the calculation. Atmospheric pressure is determined by the elevation above sea level. When the elevation along the Pipeline varies, use an average elevation along the Pipeline to determine the atmospheric pressure.
- The Maximum Time Duration (MTD) represents the maximum elapsed “purge” time allowed for the calculation. For example, if a value of 60 seconds is used, the pressure, flow, and velocity results will be calculated for conditions up to 60 seconds from the start of the purge operation. The actual Arrival (and/or) Purge Time of the interface may be shorter or longer than the MTD. Generally, use an MTD value that is greater than the anticipated Purge Time. A shorter MTD may be used to provide more detail about the conditions existing in the early stages of a purge operation. The MTD can also be used as a limit to prevent the calculation of an odd configuration from endlessly executing.
- In an effort to manage User disk storage used on the server, the combination of the Plot Time Interval and the Maximum Time Duration (PTI x MTD) cannot exceed 50,000 per project/solution.

Pipe Selection Page

The Pipe Selection page is used to calculate and specify an *Inside Diameter* value by selecting various pipe properties. To access the Pipe Selection page, click the *Select* command button on the Inlet, Pipeline, Riser, or Vent steps. The features associated with the Pipe Selection page are described as follows.



Pipe Selection...

Material Type: Cast Iron ▼

Nominal Size: 4 ▼

Wall Thickness: 0.35 ▼ Inches

Inside Diameter: 4.100 Inches

Apply Cancel

Data Items

Inside Diameter - Displays the *Inside Diameter* value associated with the selected pipe properties. The value will change as the pipe properties are changed. This item is calculated.

Material Type - Specifies the type of pipe material to be used for the size and wall thickness selection.

Nominal Size - Specifies the nominal size of the pipe to be used for the associated segment.

SDR - Specifies the Standard Dimension Ratio (SDR) for the selected pipe size. This item is only displayed when “Plastic” is selected for the *Material Type*.

Wall Thickness - Specifies the wall thickness for the selected pipe size. This item is only displayed when either “Steel” or “Cast Iron” is selected for the *Material Type*.

Command Buttons

Apply - Closes the page and applies the displayed *Inside Diameter* value.

Cancel - Closes the page without applying the displayed *Inside Diameter* value.

Notes & Considerations

- The calculation of the Inside Diameter value uses the Iron Pipe Size (IPS) convention for the outside diameter value for both plastic and steel material types. In some cases (for example, for Copper Tubing Size - CTS sizes), the Pipe Selection page cannot be used to calculate the Inside Diameter value. In these cases, the appropriate value must be manually entered for the Inside Diameter item on the corresponding “pipe” step.

Pipeline Step

The Pipeline step is used to specify various properties associated with the Pipeline. To access the Pipeline step, select the *Pipeline* link from the Sidebar. The features associated with the Pipeline step are described as follows.

Data Items

Flowing Temperature - Specifies the average flowing temperature of the Purge Gas and Pipeline Gas.

Hydraulic Efficiency - Specifies the hydraulic efficiency of the Pipeline. The value is expressed as a “factor”, for example, enter 1.00 for 100%.

Inside Diameter - Specifies the inside diameter of the Pipeline. When the Pipeline diameter varies, the smallest pipe diameter should be used to provide a conservative purge pressure and time.

Length - Specifies the physical length of the Pipeline.

Number Of Displacements - Specifies the number of displacements (additional volume exchanges) used during the calculation.

Number Of Segments - Specifies the number of segments or sections to divide the Pipeline into during the calculation. Either select “Auto” or select a value from the list. *Note* - If the “Auto” option is selected, the number of segments will be computed and reported in the calculation results.

Wall Roughness - Specifies the effective pipe wall roughness of the internal wall surface of the Pipeline.

Command Buttons

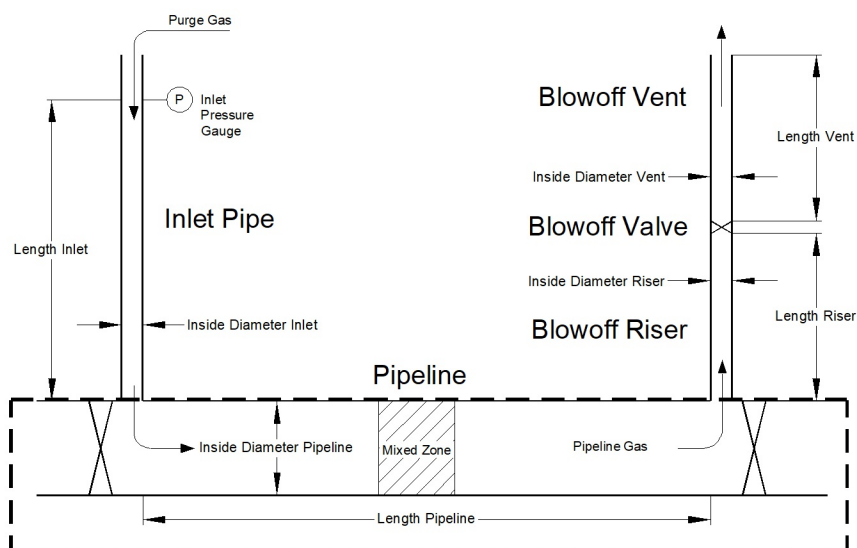
Next - Navigates through the Wizard Steps. Clicking this command button will display the next step.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Select - Displays the Pipe Selection page. Use the various data lists on the page to select a value, then click the *Apply* command button to assign the displayed *Inside Diameter* value and return to the Pipeline page.

Notes & Considerations

Figure 4 - Pipeline Component.



- One “displacement” is considered to be the original volume of gas contained in the Pipeline. The “arrival time” is the time required for the gas-to-gas interface to reach the outlet end of the Pipeline. This is essentially the same time as required to purge (vent) the original volume of the Pipeline (one displacement). The “purge time” is the arrival time plus the time required to purge (vent) one-half the volume of the Mixed Zone. The *Number Of Displacements* parameter is used to indicate whether the Purge Time should be extended beyond the time required to purge only the Pipeline. If the value of the Number Of Displacements is greater than one (1), the Purge Time will be extended beyond the required Purge Time until the volume of gas vented equals the original volume of the Pipeline times the Number Of Displacements.

- A transient analysis is used to estimate the pressures and flows along the Pipeline as the inlet and outlet conditions change. When performing a transient analysis, the overall Pipeline must be divided into smaller sections or segments to account for the varying conditions along the Pipeline. Generally, when fewer segments are used, the calculation results are less accurate reflections of actual conditions; when more segments are used, the results are more accurate reflections of actual conditions. There is, however, a trade-off between the number of segments and the calculation time. More segments mean longer calculation times. Fewer segments results in shorter calculation times, but may lead to “noise” (unusual valleys or peaks) in the calculation results. The minimum number of pipe segments allowed is 10, and the maximum number is 500. If the “Auto” option is selected, the number of segments will be computed and reported in the calculation results. Using the “Auto” option will yield a good compromise between speed and accuracy.
- The effective pipe wall roughness of the inside surface of the Pipeline is used to calculate the friction factor value used in the pipe flow equation. The value of the wall roughness varies depending on the pipe material, in service conditions, and pipe age.
- When the Pipeline contains more than one pipe size, it is recommended that the smallest size be used to perform the purge calculations. This will cause the Arrival and Purge Times to be conservative (overestimated). However, it will also overestimate the velocity at the gas-to-gas interface, which is unconservative. In this case, two analyses might be performed, one using the largest pipe size to estimate the minimum interface velocity, and another using the smallest size to estimate the Purge Time. Due to the transient analysis method used for the pipeline component, neither of these results will accurately reflect the actual conditions in the Pipeline.
- It is not appropriate to use the equivalent length method in the transient analysis used for the pipeline component. Therefore, fittings are not allowed to be attached to the Pipeline.
- The calculation method employed for the pipeline component uses a “soft start” method to begin the transient analysis. This is done to simulate the slow opening of the valve used to control the purge process. The start-up (ramp-up) time is 5 seconds in all cases. For Pipelines less than about 5,000 feet in length, the gas-to-gas interface may reach the end of the Pipeline, and/or the purge may be completed before the purge control level is fully reached.

Project Step

The Project step is used to enter information about the purge “project”. The information entered on the Project step is used only to document the purge conditions. This information does not affect the calculation results. To access the Project step, select the *Project* link from the Sidebar. The features associated with the Project step are described as follows.



The screenshot shows the 'Project' step interface. On the left is a sidebar with a list of links: 'Project' (highlighted in blue), 'Configuration', 'Parameters', 'Inlet', 'Pipeline', 'Riser', 'Valve', 'Vent', 'Review', and 'Results'. The main area contains a 'Next' button at the top right. Below it are input fields for 'Title:', 'Project ID:', 'By:', and 'Date:'. The 'Date' field is pre-filled with '8/27/2025'. Below these fields is a 'Notes:' label followed by a large text area with a small icon in the bottom right corner. At the bottom of the form is a 'Clear' button.

Data Items

By - Specifies who performed the purge calculation.

Date - Specifies the date when the calculation was performed.

Notes - Specifies comments or notes associated with the purge calculation.

Project ID - Specifies an identification number or name for the “project”.

Title - Specifies a title for the “project”.

Command Buttons

Clear - Sets the calculation input data values on all of the steps to blank (null or empty) values.

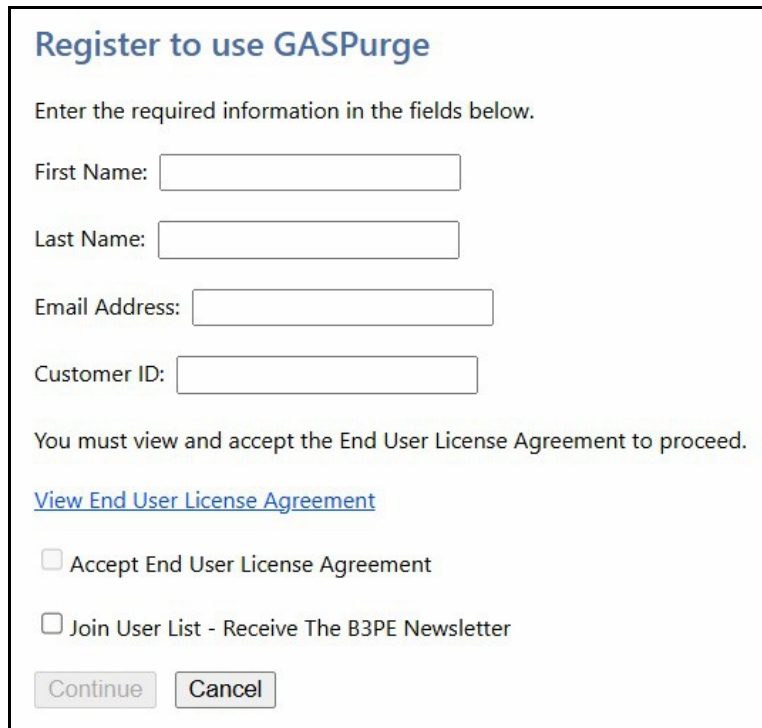
Next - Navigates through the Wizard Steps. Clicking this command button will display the next step in the Wizard.

Notes & Considerations

- None of the values on the Project step are required to perform the calculation. Any alphanumeric value may be entered for any of the data fields.

Registration Page

The Registration page is used to register an email address for Users of the Service. To access the Registration page, select the *Register* link in the upper-right corner of the main GASPurge window, or click the link on the Login page. The features associated with the Registration page are described as follows.



The screenshot shows a registration form titled "Register to use GASPurge". It includes instructions to enter required information in the fields below. There are four input fields: "First Name", "Last Name", "Email Address", and "Customer ID". Below the fields, a message states: "You must view and accept the End User License Agreement to proceed." followed by a link "View End User License Agreement". There are two checkboxes: "Accept End User License Agreement" and "Join User List - Receive The B3PE Newsletter". At the bottom are "Continue" and "Cancel" buttons.

Data Items

Accept Terms & Conditions - Indicates whether the User accepts the “terms and conditions” for use of the Service. *Note* - This item must be selected to enable the *Continue* command button.

Customer ID - Specifies the unique identification number that was assigned to your Customer Account. Entered values must be a combination of alphanumeric characters.

Email Address - Specifies the email address to be associated with the new User Account. Entered values must be in a valid email format, or they will not be accepted.

First Name - Specifies the first name (given name) of the User being registered.

Join User List - Indicates whether to add the entered email address to the GASPurge User List and receive occasional emails, including the B3PE monthly newsletter. This is optional and not required to register to use the Service.

Last Name - Specifies the last name (surname) of the User being registered.

Command Buttons

Cancel - Cancels the registration and returns to the Login page.

Continue - Creates a new User Account. If successful, you will automatically be redirected to the Login page.

Links

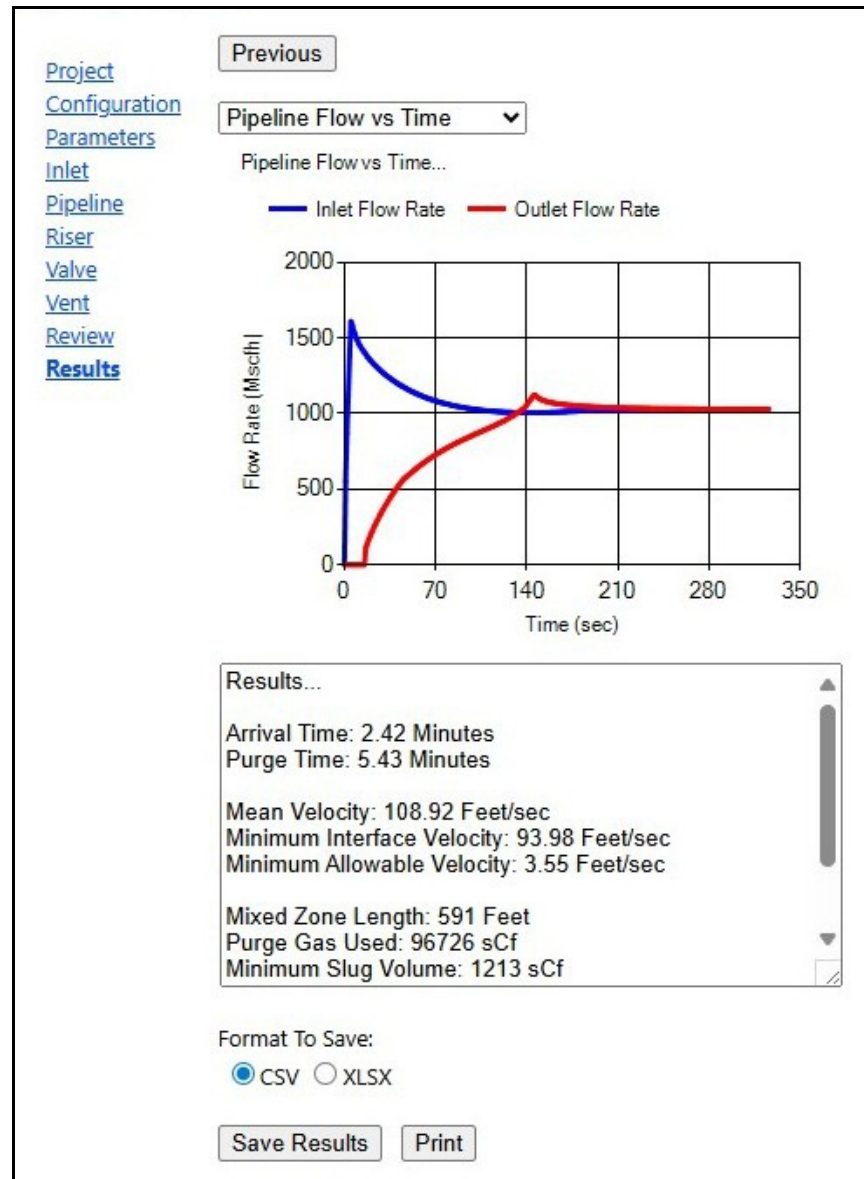
View Terms & Conditions - Displays the Terms & Conditions for use of the Service. This link must be clicked to enable the *Accept Terms & Conditions* checkbox.

Notes & Considerations

- The User's email address is used to create a folder on the server to keep User-specific configuration and initialization settings. It is recommended that each User register for a separate account, but it is not required.
- The Customer ID is a unique value that is provided when you purchase a subscription to use the Service. If you do not know your Customer ID, please contact the person at your company responsible for managing the subscriptions or email help@b3pe.com for assistance.
- The "Terms & Conditions" of use are described in the "GASPurge End User License Agreement" (EULA). You must agree to the EULA terms and conditions to use the Service. By checking the "Accept Terms & Conditions" option and clicking the *Continue* command button, you agree to the terms and conditions described in the EULA.

Results Step

The Results step displays the graphical and numerical results of the calculation. To access the Results step, select the *Results* link from the Sidebar. The features associated with the Results step are described as follows.



Data Items

Format To Save - Specifies the output file format created when the *Save Results* command button is clicked.

Graphs

Pipeline Flow vs Time - Displays a graph or plot of the Pipeline inlet and outlet flow rates as a function of time.

Pipeline Pressure vs Time - Displays a graph or plot of the Pipeline inlet and outlet pressures as a function of time.

Pipeline Velocity vs Time - Displays a graph or plot of the Pipelines inlet, outlet, and gas-to-gas interface velocities as a function of time.

Exit Velocity vs Time - Displays a graph or plot of the velocity at the outlet of the Blowdown Vent as a function of time. Only calculated if a Blowoff Vent is present.

Results

Arrival Time - Represents the elapsed time required for the gas-to-gas interface to reach the outlet end of the Pipeline. The arrival time does not include the time for venting additional “displacements”.

Mean Velocity - The mean (average) purge velocity is calculated by dividing the length of the Pipeline by the Arrival Time. This value, therefore, represents the average gas velocity in the Pipeline. Because the Purge Gas and Pipeline Gas are compressible, the actual gas velocity in the Pipeline will vary from the inlet to the outlet.

Minimum Allowable Velocity - Represents the lower of the stratification velocity or the velocities required to produce a Reynolds Number of 4000 (considered the minimum required Reynolds Number to produce a fully turbulent flow) at the gas-to-gas interface location.

Minimum Interface Velocity - The velocity of the gas-to-gas interface will vary over the duration of the purge. This value represents the lowest calculated velocity at the gas-to-gas interface location, occurring *after* the “start-up” period.

Minimum Slug Volume - The “slug volume” is the minimum amount of inert gas needed to separate the Purge Gas and Pipeline Gas. The slug volume is equivalent to the estimated volume of gas contained in the Mixed Zone.

Mixed Zone Length - The Purge Gas and Pipeline Gas tend to mix at the gas-to-gas interface. This value represents the length of the mixed gas region in the absence of a separating inert slug.

Natural Gas Vented - Represents the amount of natural gas vented during the “purge time”.

Purge Gas Used - Represents the amount of gas injected into the Pipeline during the “purge time”.

Purge Time - Represents the Arrival Time plus the time required to vent one-half of the Mixed Zone volume, plus any additional time required to vent the Number Of Displacements specified on the Pipeline step.

Segment Count - Represents the number of calculation segments used during the transient analysis of the Pipeline flows and pressures.

Command Buttons

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Print - Prints both the calculation input data values and the calculation results. When selected, the Print Preview page will be displayed. Click the *Print* command button on the Print Preview page. Depending on the device, browser, and operating system, additional prompts may appear to select print options and printer location. Click the *Close* command button to exit the Print Preview page.

Save Results - Saves the data values used to construct the graphical results. When selected, depending on the device, browser, and operating system, additional prompts may appear to select the file location or other options. The results will be saved in the selected *Format To Save* file type.

Notes & Considerations

- The results are calculated whenever the *Calculate* command button is clicked on the Review step, the *Calculate* link is clicked on the Schematic, or the *Results* link is clicked and data changes have been made since the last calculation.
- The calculation routine first checks the input data to make sure it is all correctly formatted and that the entered values are within acceptable bounds. If an issue is found, the routine is stopped, the step where the issue was found is displayed, and the field that needs attention is highlighted.
- Volumes reported in the results are saved in “standard” units based on the *Base Pressure* and *Base Temperature* values specified on the Parameters step.
- The amount of Natural Gas Vented is calculated as follows:
 - If the Pipeline Gas is natural gas and the Purge Gas is anything other than natural gas, the value only includes the volume of gas originally in the Pipeline.
 - If the Pipeline Gas is anything other than natural gas and the Purge Gas is natural gas, the value includes one-half the volume of gas in the Mixed Zone plus any gas vented beyond the “purge time”, due to a Number of Displacements value greater than one (1).

- If the Pipeline Gas is natural gas and the Purge Gas is natural gas, the value includes the volume of gas originally in the Pipeline, plus any gas vented beyond the “arrival time”, due to a Number of Displacements value greater than one (1).
 - If the Pipeline Gas is anything other than natural gas and the Purge Gas is anything other than natural gas, no natural gas is reported as vented.
- The Slug Volume is calculated using the Mixed Zone Length and the Inside Diameter of the Pipeline, at atmospheric pressure.
 - The inlet and outlet values reported in the various graphs represent the values at the inlet and outlet of the Pipeline. If an Inlet Pipe or Blowoff Assembly is present, these values will not necessarily represent values that might be measured along those elements.
 - The graphical results show the unsteady nature of the purge operation. The plot showing the inlet flow rate can be used to determine the maximum gas flow rate needed during the purge. The maximum flow rate during the purge can be crucial when the available low rate for a purge is limited. To limit transient pulsations in the Pipeline simulation model, a “soft start” is included in the model to “ramp-up” the flow or pressure rather than start with an immediate change in either pressure or flow rate. The soft start simulates the gradual opening of the purge control valve.
 - The mean velocity represents the length of the Pipeline divided by the Arrival Time. This is not representative of the velocity at the gas-to-gas interface. Use the velocity of the gas-to-gas interface to ensure that an adequate velocity is maintained, thereby limiting gas mixing and/or stratification.
 - The exit velocity represents the velocity at the point where the gas leaves the Blowoff Vent and enters the atmosphere. The exit velocity is only calculated if a Blowoff Vent is present. The Exit Velocity vs Time graph shows how the exit velocity changes during the purge process. There are three considerations when reviewing these results:
 - The first consideration is when combustible gas (a fuel) is being vented. As fuel gas is vented, a potentially flammable fuel gas-to-air mixture could form in the vicinity of the vent exit. If the mixture ignited, the flame would tend to move toward the source of the fuel (the vent) at the speed of the fuel’s flame. To prevent the flame from moving down the vent and into the Pipeline, it is important to ensure that the exit velocity is greater than the flame speed of the fuel gas. Natural gas (methane) has a flame speed of about 1 Ft/sec.
 - The second consideration is whether choked flow is occurring at the vent exit. This occurs when the exit velocity reaches the sonic velocity of the gas being vented. Under choked flow conditions, the exit velocity will remain constant at sonic velocity. This does not mean that the purge process will not be effective, only indicates that the flow rate is limited to a level that produces sonic velocity.
 - The third consideration is for noise. If maintaining low noise levels at the vent location is important, the exit velocity should be limited to below 100 to 200 ft/sec.

- The gas-to-gas interface velocity varies over the duration of the purge process. At the start of the purge, the interface velocity is zero; it then increases during the “start-up” period, usually to a maximum value, then decreases as the pressure in the Pipeline increases. The Minimum Interface Velocity value shown in the reported results represents the lowest value occurring after the start-up period. If needed, the interface velocity occurring during the start-up period can be determined from the graphical results or from the values contained in a saved results file.

- The graphical depictions of the results are useful to understand the conditions experienced during the complete purge process. They allow you to estimate the expected conditions at various locations and times during the purge process. Although the graphs are interesting to examine, the values listed in the Results section provide the most critical information associated with the purge.

- The Service currently supports two file formats for saving results - CSV and XLSX.

- Time-dependent data can be stored in a Comma Separated Values (.csv) format file on the server. This data can be saved by selecting “CSV” for the *Format To Save* style. This file can be opened, viewed, and manipulated by most spreadsheet-style applications. The resulting file contains the time-dependent data used to construct the graphical results. The results are formatted with a header row followed by a row (record) for each time increment. Each record contains, in the following order, the:

- time increment value
- inlet pressure
- outlet pressure
- inlet volumetric flow rate
- outlet volumetric flow rate
- inlet velocity
- outlet velocity
- interface velocity
- vent exit velocity
- outlet specific gravity

- A Microsoft Excel Format (.xlsx) file can be saved by selecting “XLSX” for the *Format To Save* style. The resulting file contains the project data separated into several worksheets:

- Input Data
- Results
- Output Data (the time-dependent data similar to the CSV file)
- Pressure vs Time Graph
- Flow vs Time Graph
- Pipeline Velocity vs Time Graph
- Exit Velocity vs Time Graph

Note...

The graphs are saved in the XLSX file as Line-type Charts. This means the data on the horizontal axis is distributed evenly, even though the time interval between points is not fixed. This has a minor effect on the graph's appearance, as the time interval changes slightly between the ramp-up period and the remainder of the purge. The "correct" Chart type for the graphs is XY Scatter, which is how they appear on the Results step. Currently, the Service does not support exporting XY Scatter Charts to XLSX format.

Review Step

The Review step lists the various input data values and settings. It can be used to double-check the input values before proceeding with the calculation. To access the Review step, select the *Review* link from the Sidebar. The features associated with the Review step are described as follows.

[Project](#)
[Configuration](#)
[Parameters](#)
[Inlet](#)
[Pipeline](#)
[Riser](#)
[Valve](#)
[Vent](#)
[Review](#)
[Results](#)

Title: Purge Example
Project ID: Ex1
By: LMA
Date: 8/28/2025

Purge Gas: Typical US Natural Gas
Specific Gravity: 0.567
Viscosity: 0.000007 Lbm/Ft-Sec

Pipeline Gas: Air
Specific Gravity: 1.000
Viscosity: 0.000012 Lbm/Ft-Sec

Control Variable: Pressure
Inlet Pressure: 20 Psig
Base Pressure: 14.73 Psia
Base Temperature: 60 Fahrenheit
Local Atmospheric Pressure: 14.73 Psia
Plot Time Interval: 1 Seconds
Maximum Time Duration: 10 Minutes

Data Items

Review List - Displays the input data values from all previous steps.

Command Buttons

Calculate - Executes the purge calculation. If successful, the Results step will be displayed. If any input data was missing or entered incorrectly, the step associated with that data will be displayed, and the field that needs attention will be highlighted.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Print - Prints the calculation input data values. When selected, the Print Preview page will be displayed. Click the *Print* command button on the Print Preview page. Depending on the device, browser, and operating system, additional prompts may appear to select print options and printer location. Click the *Close* command button to exit the Print Preview page.

Notes & Considerations

- The Review step is for informational purposes only. If changes need to be made to the input data, select the associated step, make the desired change, and then return to the Review step to review again.

Riser Step

The Riser step is used to enter properties associated with the riser portion of the Blowoff Assembly. To access the Riser step, select the *Riser* link from the Sidebar. The features associated with the Riser step are described as follows.

[Project](#)
[Configuration](#)
[Parameters](#)
[Inlet](#)
[Pipeline](#)
[Riser](#)
[Valve](#)
[Vent](#)
[Review](#)
[Results](#)

PreviousNext

Blowoff Riser:
☒ Yes ☐ No

Inside Diameter:

Select

Inches

Wall Roughness: Inches

Length: Feet

Hydraulic Efficiency:

Riser Fittings:

Fitting	Quantity
Elbow 90 SR	0
Elbow 90 LR	0
Elbow 45	0
Run Tee	0
Branch Tee	0
Ball Valve	0
Gate Valve	0
Plug Valve	0
Miscellaneous	0

Reset

Data Items

Blowoff Riser - Indicates whether or not a Blowoff Riser is present in the Blowoff Assembly. If no Blowoff Riser is present, the remaining data values will be ignored.

Hydraulic Efficiency - Specifies the hydraulic efficiency of the Blowoff Riser. The value is expressed as a “factor” (for example, enter 0.5 for 50%).

Inside Diameter - Specifies the inside diameter of the Blowoff Riser.

Length - Specifies the hydraulic length of the Blowoff Riser.

Riser Fittings - Indicates the number and type of fittings attached to the riser portion of the Blowoff Assembly.

Wall Roughness - Specifies the effective pipe wall roughness of the Blowoff Riser.

Command Buttons

Next - Navigates through the Wizard Steps. Clicking this command button will display the next step in the Wizard.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

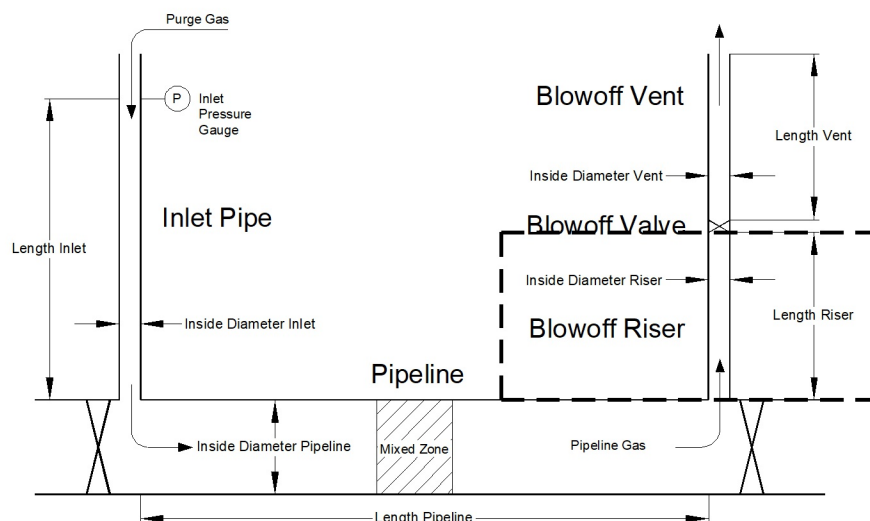
Reset - Clears the *Riser Fittings* lists.

Select - Displays the Pipe Selection page. Use the various data lists on the page to specify a value, then click the *Apply* command button to assign the selected value and return to the Riser page.

Notes & Considerations

- With respect to the purge calculations, the group of components used to vent or discharge the gas to the atmosphere is referred to as the Blowoff Assembly. The Blowoff Assembly is divided into three components; the riser, the valve, and the vent. The “blowoff riser” is attached directly to the Pipeline, upstream of the valve. The “blowoff valve” is connected immediately downstream of the riser and upstream of the vent. The “blowoff vent” is connected immediately downstream of the valve and vents directly to the atmosphere. Any or all of the components can be present or not.
- The Hydraulic Efficiency is used to adjust or tune the performance of the pipe flow equation to better match actual field results. For the Blowoff Assembly (riser and vent pipe), the value should normally be between 0.5 and 0.7.
- Fittings attached to the Blowoff Riser are assumed to have the same Inside Diameter as the specified *Inside Diameter* value.

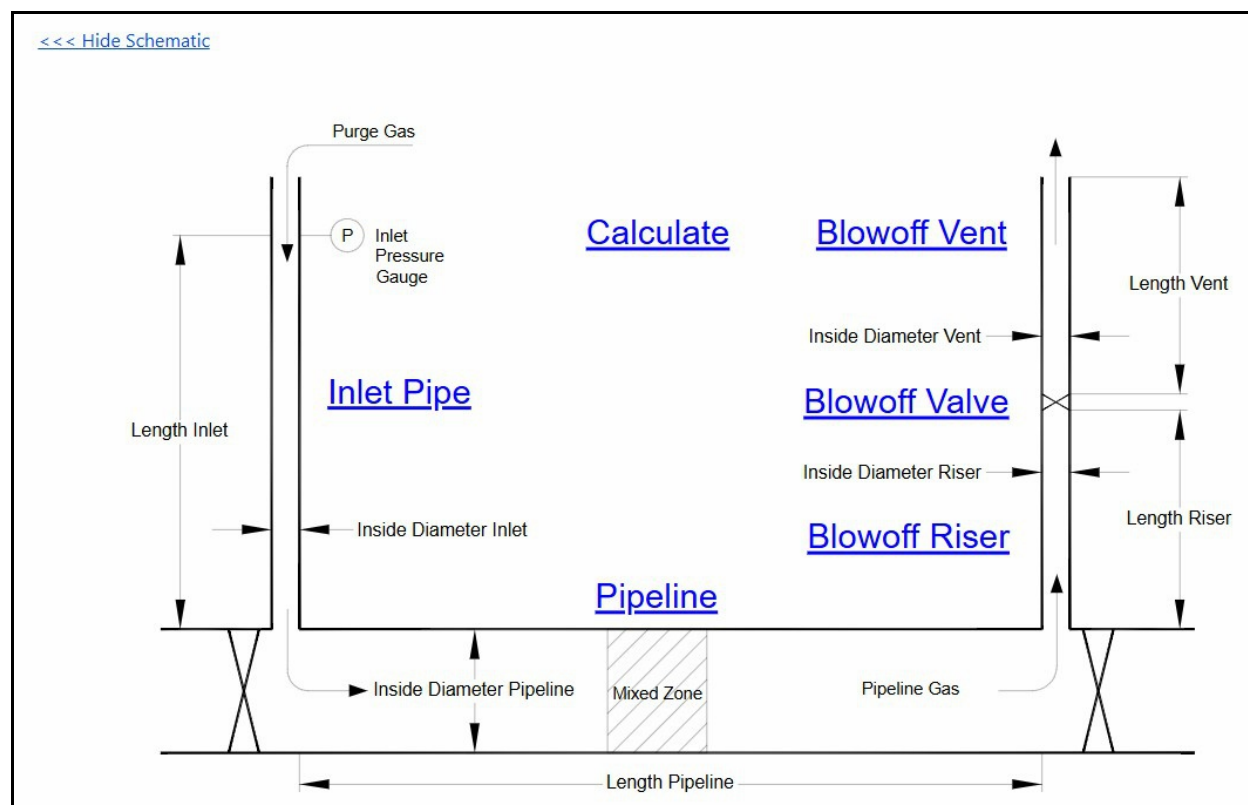
Figure 5 - Blowoff Riser Portion Of The Blowoff Assembly.



- The pressure drop associated with the assigned fittings is calculated using an equivalent hydraulic length value. The associated equivalent length value is calculated based on the assigned Le/D value. The default Le/D values can be viewed or revised using the Fittings page.
- If no portion of the Blowoff Assembly is indicated, the Purge Gas is assumed to be vented directly out of the downstream (outlet) end of the Pipeline.
- The effective pipe wall roughness of the inside surface of the Blowoff Riser is used to calculate the friction factor value used in the pipe flow equation. The value wall roughness varies depending on the pipe material, in service conditions, and pipe age.
- The Blowoff Riser is handled separately to allow the use of multiple sizes along the Blowoff Assembly. The riser, valve, and vent can all be different sizes. If all three components are the same size, the vent component can be used to represent all three components combined.
- Any valves assigned as “fittings” on the Riser step are in addition to the Blowoff Valve entered on the Valve step.

Schematic

The Schematic (System Schematic) provides a graphic definition of the various data values required for the analysis. The Schematic is part of the main Project page. It can be hidden or displayed by selecting the *Schematic* link. The blue underlined labels on the Schematic can be clicked to display the associated step in the Wizard.



Links

Hide Schematic - Hides the display of the Schematic.

Show Schematic - Shows the Schematic.

Notes & Considerations

- Click on the blue underlined labels to display the associated Wizard step.

Valve Step

The Valve step is used to specify whether a valve is present in the Blowoff Assembly and, if so, to specify its properties. To access the Valve step, select the *Valve* link from the Sidebar. The features associated with the Valve step are described as follows.

Project
Configuration
Parameters
Inlet
Pipeline
Riser
Valve
Vent
Review
Results

Previous Next

Blowoff Valve:
☒ Yes ☐ No

Valve Type: Ball ▼

Effective Valve Size: Inches ▼

Data Items

Blowoff Valve - Indicates whether or not a valve is present in the Blowoff Assembly. If no valve is present, the remaining data values will be ignored.

Effective Valve Size - Specifies the effective size, as a diameter value, of the Blowoff Valve.

Valve Type - Specifies the type of Blowoff Valve.

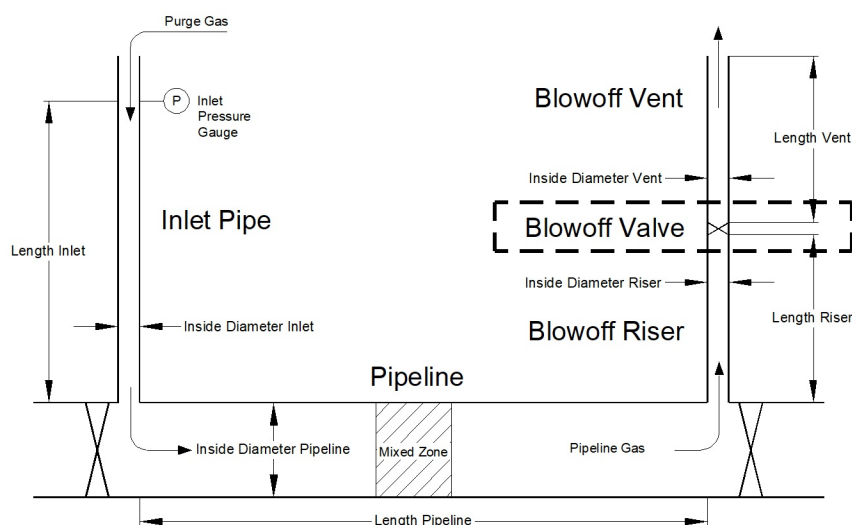
Command Buttons

Next - Navigates through the Wizard Steps. Clicking this command button will display the next step in the Wizard.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

Notes & Considerations

Figure 6 - Blowoff Valve Portion Of The Blowoff Assembly.



- Regarding the purge calculations, the group of components used to vent or discharge the gas into the atmosphere is referred to as the Blowoff Assembly. The Blowoff Assembly is divided into three components; the riser, the valve, and the vent. The “blowoff riser” is attached directly to the Pipeline, upstream of the valve. The “blowoff valve” is connected immediately downstream of the riser and upstream of the vent. The “blowoff vent” is connected immediately downstream of the valve and vents directly to the atmosphere. Any or all of the components can be present or not.
- The pressure drop associated with the Blowoff Valve is calculated using an equivalent hydraulic length value. The associated equivalent length value is calculated based on the assigned Le/D value. The default Le/D values can be viewed or revised using the Fittings page.
- If no portion of the Blowoff Assembly is indicated, the Purge Gas is assumed to be vented directly out of the downstream (outlet) end of the Pipeline.
- The Blowoff Valve is handled separately to allow the use of multiple sizes along the Blowoff Assembly. The riser, valve, and vent can all be different sizes. If all three components are the same size, the vent component can be used to represent all three components combined.
- The *Effective Valve Size* value represents a diameter value that effectively produces the same flow area as the valve. If the “diameter” of the blowoff valve is less than the riser and/or vent, it may be a likely location for choked flow to occur. The flow area of the valve controls the gas flow rate when the valve is choked. If several valves are located in the Blowoff Assembly, enter the properties of the valve with the smallest flow area as the “blowoff valve”. Include any other valves as fittings on either the Riser step or the Vent step.

Vent Step

The Vent step is used to enter properties associated with the vent portion of the Blowoff Assembly. To access the Vent step, select the *Vent* link from the Sidebar. The features associated with the Vent step are described as follows.

[Project](#)
[Configuration](#)
[Parameters](#)
[Inlet](#)
[Pipeline](#)
[Riser](#)
[Valve](#)
[Vent](#)
[Review](#)
[Results](#)

PreviousNext

Blowoff Vent:
☒ Yes ☐ No

Inside Diameter:

Select

Inches

Wall Roughness: Inches

Length: Feet

Hydraulic Efficiency:

Vent Fittings:

Fitting	Quantity
Elbow 90 SR	0
Elbow 90 LR	0
Elbow 45	0
Run Tee	0
Branch Tee	0
Ball Valve	0
Gate Valve	0
Plug Valve	0
Miscellaneous	0

Reset

Data Items

Blowoff Vent - Indicates whether or not a Blowoff Vent is present in the Blowoff Assembly. If no Blowoff Vent is present, the remaining data values will be ignored.

Hydraulic Efficiency - Specifies the hydraulic efficiency value of the Blowoff Vent. The value is expressed as a “factor”(for example, enter 0.5 for 50%).

Inside Diameter - Specifies the inside diameter of the Blowoff Vent.

Length - Specifies the hydraulic length of the Blowoff Vent.

Vent Fittings - Indicates the number and type of fittings attached to the vent portion of the Blowoff Assembly.

Wall Roughness - Specifies the effective pipe wall roughness of the Blowoff Vent.

Command Buttons

Next - Navigates through the Wizard Steps. Clicking this command button will display the next step in the Wizard.

Previous - Navigates through the Wizard Steps. Clicking this command button will display the previous step in the Wizard.

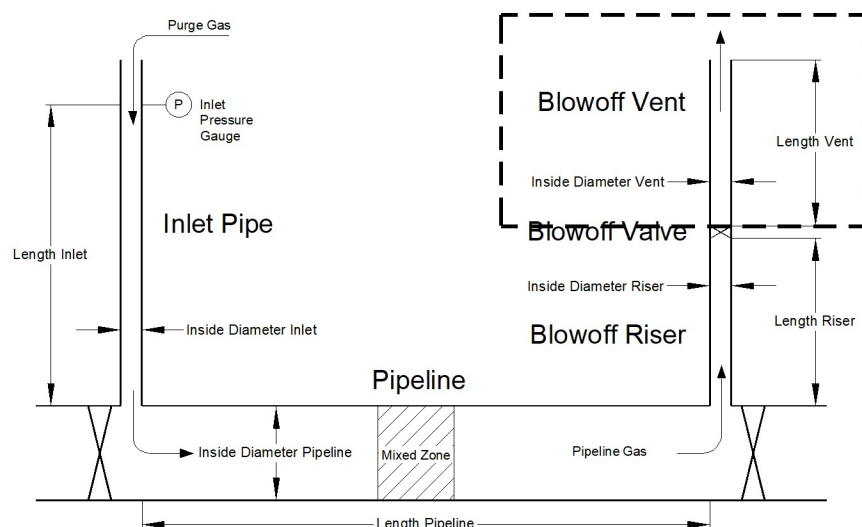
Reset - Clears the *Vent Fittings* lists.

Select - Displays the Pipe Selection page. Use the various data lists on the page to specify a value, then click the *Apply* command button to assign the displayed value and return to the Vent page.

Notes & Considerations

- With respect to the calculations performed by the Service, the group of components used to vent or discharge the gas to the atmosphere is referred to as the Blowoff Assembly. The Blowoff Assembly is divided into three components; the riser, the valve, and the vent. The “blowoff riser” is attached directly to the Pipeline, upstream of the valve. The “blowoff valve” is connected immediately downstream of the riser and upstream of the vent. The “blowoff vent” is connected immediately downstream of the valve and vents directly to the atmosphere. Any or all of the components can be present or not.
- The hydraulic efficiency is used to adjust or tune the performance of the pipe flow equation to better match actual field results. For the Blowoff Assembly (riser and vent pipe), the value should normally be between 0.5 and 0.7.
- Fittings attached to the vent portion of the Blowoff Assembly are assumed to have the same Inside Diameter as the specified *Inside Diameter* value.

Figure 7 - Blowoff Vent Portion Of The Blowoff Assembly



- The pressure drop associated with the assigned fittings is calculated using an equivalent hydraulic length value. The associated equivalent length value is calculated based on the assigned Le/D value. The default Le/D values can be viewed or revised using the Fittings page.
- If no portion of the Blowoff Assembly is indicated, the Purge Gas is assumed to be vented directly out of the downstream (outlet) end of the Pipeline.
- The effective pipe wall roughness of the inside surface of the Inlet Pipe is used to calculate the friction factor value used in the pipe flow equation. The value of wall roughness varies depending on the pipe material, in service conditions, and pipe age.
- The Blowoff Vent is handled separately to allow for the use of multiple sizes along the Blowoff Assembly. The riser, valve, and vent can all be different sizes. If all three components are the same size, the vent component can be used to represent all three components combined.
- During the calculation, the equivalent length for a “pipe exit” is added to the hydraulic length of the vent pipe.
- Any valves assigned as “fittings” on the Vent step are in addition to the Blowoff Valve entered on the Valve step.

EXAMPLE CALCULATIONS

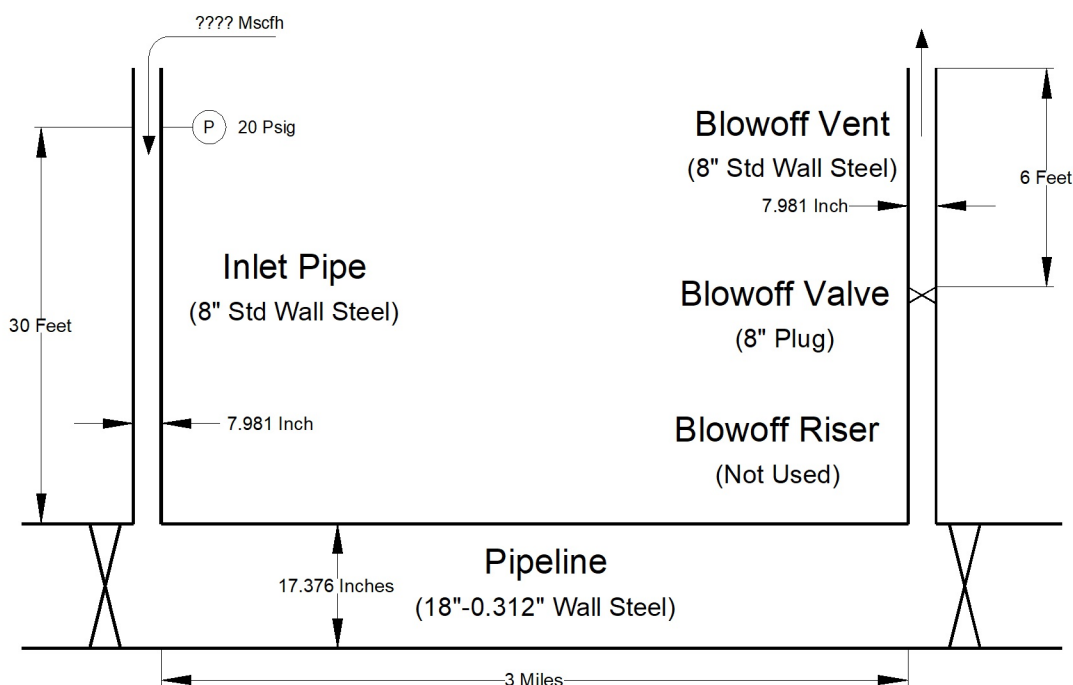
Example 1 - Pressure-Controlled Purge

Background

The following example will guide you through the general steps involved in calculating the results associated with a pressure-controlled purge configuration. The goal will be to calculate the time required to purge a pipeline containing air, using natural gas, through an 8" steel Inlet Pipe, using a single 6-foot vent of 8" standard wall steel pipe, with an 8-inch plug valve attached directly to the Pipeline, at the following conditions.

3 miles - 18-inch 0.312-inch wall pipe
 Inlet Pressure = 20 psig (Controlled)
 Base Pressure = 14.73 psia
 Base Temperature = 60 Fahrenheit
 Atmospheric Pressure = 14.73 psia
 Flowing Temperature = 60 Fahrenheit
 Inlet and Blowoff Efficiency = 0.6

Figure 8 - Example 1



Data Entry

This example illustrates how to enter data and calculate the results for a pressure-controlled Pipeline purge as described below. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex1**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today's Date** in your preferred format.
 - For *Notes*, type **Pressure Control Example**.
 - Click the *Next* command button.
- On the Configuration step:
 - For *Purge Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Typical US Natural Gas” option is selected.

- For *Pipeline Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Air” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Pressure**.
 - For *Inlet Pressure*, enter **20 Psig**.
 - For *Base Pressure*, enter **14.73 Psia**.

- For *Base Temperature*, enter **60 Fahrenheit**.
- For *Local Atmospheric Pressure*, enter **14.73 Psia**.
- For *Plot Time Interval*, enter **1 Seconds**.
- For *Maximum Time Duration*, enter **10 Minutes**.
- Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **Yes**.
 - For *Inside Diameter*, enter **7.981 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **30 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - For *Inlet Fittings*, select **1** next to the *Branch Tee* item.
 - Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, click the *Select* command button.
 - On the Pipe Selection page:
 - For *Material Type*, select **Steel**.
 - For *Nominal Size*, select **18**.
 - For *Wall Thickness*, select **0.312**.
 - The *Inside Diameter* value is **17.376 Inches**.
 - Click the *Apply* command button.
 - The *Wall Roughness* value is **0.0007 Inches**. It is automatically entered when the “Steel” material type is selected on the Pipe Selection page.
 - For *Length*, enter **3 Miles**.

- For *Hydraulic Efficiency*, enter **1.0**.
- For *Flowing Temperature*, enter **60 Fahrenheit**.
- For *Number Of Displacements*, select **2**.
- For *Number Of Segments*, select **Auto**.
- Click the *Next* command button.
- On the Riser step:
 - For *Blowoff Riser*, select **No**.
 - Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Plug**.
 - For *Effective Valve Size*, enter **8 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **7.981 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - Click the *Next* command button.
- On the Review step:
 - Use the scroll bar to review the entered values.

- Revise values by selecting the associated step (step) and changing the value.
- Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.
 - Either save the results, print the results, or edit the calculation input values and calculate again.

Results

The results should be similar to the following:

Arrival Time:	2.42 Minutes
Purge Time:	5.43 Minutes
Mean Velocity:	108.92 Feet/sec
Minimum Interface Velocity:	93.98 Feet/sec
Minimum Allowable Velocity:	3.55 Feet/sec
Mixed Zone Length:	591 Feet
Purge Gas Used:	96726 sCf
Minimum Slug Volume:	1213 sCf
Natural Gas Vented:	26691 sCf
Segment Count:	16

Conclusion & Comments

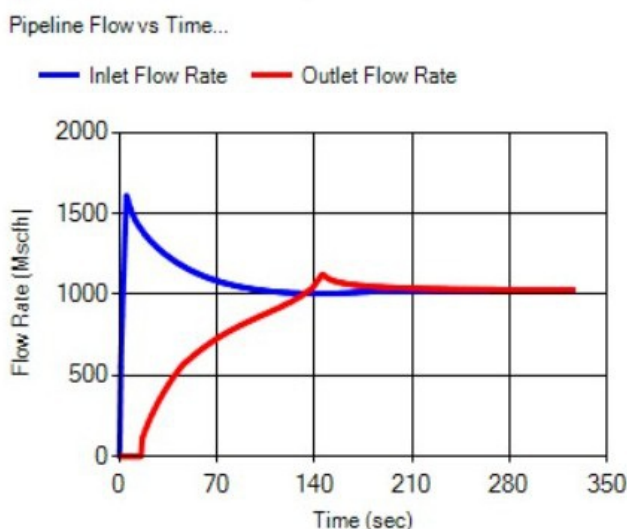
This purge configuration appears to have worked successfully.

Result Values

- The gas-to-gas interface arrived at the end of the Pipeline in about 2.5 minutes after the purge process began. It took about 5.5 minutes for a volume equal to two displacements (two Pipeline volumes) to be vented. This is the total time to complete the purge, not in addition to the Arrival Time.
- The Minimum Interface Velocity is about 94 feet/sec. This is greater than the Minimum Allowable Velocity of about 3 feet/sec. This indicates that the velocity at the gas-to-gas interface should be sufficient to limit mixing and to prevent stratification of the gases.

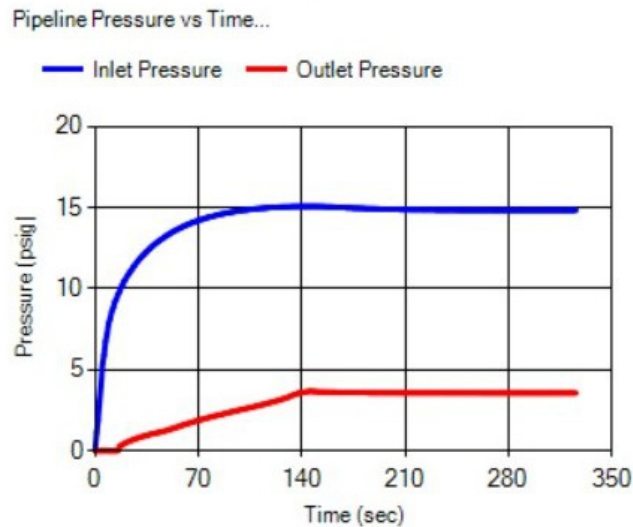
- The Mixed Zone Length is about 590 feet, which means that up to about 295 feet on either side of the theoretical gas-to-gas interface location, there could be mixing of the Purge Gas and Pipeline Gas. To offset the Mixed Zone, at least 1200 sCf (the Slug Volume) of Nitrogen would need to be injected before starting the purge.
- A total of about 97 Mscf (96726 sCf) of Natural Gas was introduced into the Pipeline during the purge operation. Of that, a total of about 27 Mscf (26691 sCf) of Natural Gas was vented. This amount includes the volume of gas contained in the Mixed Zone (one-half the Mixed Zone volume) and the gas resulting from extending the Purge Time to two displacements.
- Because the “Auto” option was selected for the Pipeline Number Of Segments, the Pipeline was divided into 16 “calculation” segments during the calculation.

Pipeline Flow vs Time Graphic Results



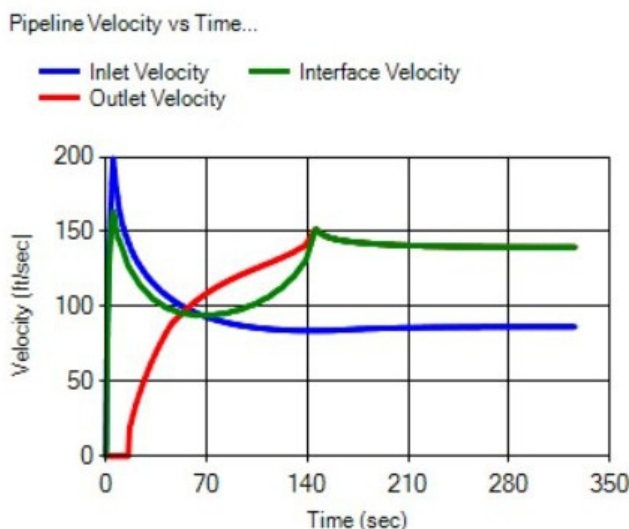
- Studying the Inlet Flow Rate shown on the Pipeline Flow vs Time graph, the very first few seconds show the “ramp-up” of the flow caused by the approximation of the gradual opening of the inlet valve. The flow eventually peaks, which represents that the inlet valve is sufficiently open to maintain the Inlet Pressure. Then the flow begins to slow as the Pipeline pressure increases, decreasing the pressure differential near the Pipeline inlet and thus reducing the flow rate. The Inlet and Outlet Flow Rates will eventually reach the same rate as steady-state conditions are reached.
- Reviewing the Outlet Flow Rate, the Pipeline Flow vs Time graph shows no flow at the Pipeline outlet for about the first 20 seconds. This is because the Pipeline Gas (air in this case) has not yet started moving at the outlet end of the Pipeline. Eventually, the “pressure wave” will reach the Pipeline end, and air will start flowing out of the vent. Beyond this point, the outlet flow gradually increases as the Pipeline pressure increases, creating a higher pressure differential between the Pipeline and the vent outlet, thus increasing the flow rate.
- Around 120 seconds, the Outlet Flow Rate starts to show a slight hook upward as the gas-to-gas interface and the Mixed Zone approach the Pipeline end. When these begin to reach the end of the Pipeline, the properties of the exiting gas begin to change in the calculation segments near the pipe end and the Blowoff Assembly. This affects the flow and pressure drop.
- When all of the Purge Gas has reached the outlet end of the Pipeline, the properties gradually become completely associated with the Purge Gas, and the Inlet and Outlet Flow Rates converge to a steady-state value.

Pipeline Pressure vs Time Graphic Results



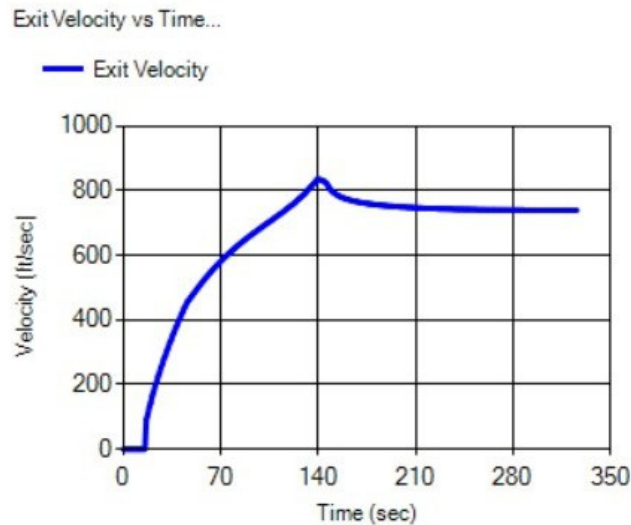
- Reviewing the Outlet Pressure, the Pipeline Pressure vs Time graph shows no pressure increase at the Pipeline outlet for about the first 20 seconds. This is because the “pressure wave” has not yet reached the end of the Pipeline. Beyond this point, the Outlet Pressure gradually increases until all of the Pipeline Gas has been vented and the pressures and flows reach steady-state conditions.
- The Inlet Pressure rapidly increases at the start of the purge until the “controlled” pressure value is reached.

Pipeline Velocity vs Time Graphic Results



- There are three values depicted on the Pipeline Velocity vs Time graph - Inlet, Outlet, and Interface Velocities.
- As in the flow and pressure cases, the Outlet Velocity does not begin to increase until the “pressure wave” reaches the end of the Pipeline. The increase in velocity coincides with the time when the air begins to flow out of the vent. Beyond this point, the Outlet Velocity gradually increases until all of the Pipeline Gas has been vented and the pressures and flows reach steady-state conditions.
- Around 140 seconds, the Outlet Velocity starts to show a slight hook upward as the gas-to-gas interface approaches the Pipeline end, similar to what happens with the Outlet Flow Rate.
- The Inlet Velocity increases rapidly for the first few seconds, then begins to decrease as pressure in the Pipeline increases. Eventually reaching a steady value as the pressures and flows reach a steady state.
- The Interface Velocity tracks the Inlet Velocity until about the time that the Inlet and Outlet Velocities intersect. The Interface Velocity then begins to increase until the Pipeline Gas (air) has been completely vented, at which point it becomes equal to the Outlet Velocity.

Exit Velocity vs Time Graphic Results



- The shape of the Exit Velocity curve is similar to that of the Outlet Velocity, but the magnitude of the Exit Velocity is much higher. This occurs due to the smaller diameter and lower pressure at the vent outlet.
- The Pipeline Gas is air, so no combustible gas is present at the vent exit until the Mixed Zone arrives at about the 140-second mark. After that time, the Exit Velocity is well above the flame speed of the Purge Gas (natural gas), indicating that if ignition occurred, it would not be possible for a flame to enter the vent.
- The Exit Velocity does not reach sonic velocity, so the flow in the vent is not choked.
- The Exit Velocity is in excess of 200 feet per second for most of the purge duration. If limiting noise at the vent location were important in this scenario, measures would need to be taken to reduce the Exit Velocity and/or to mitigate the noise.

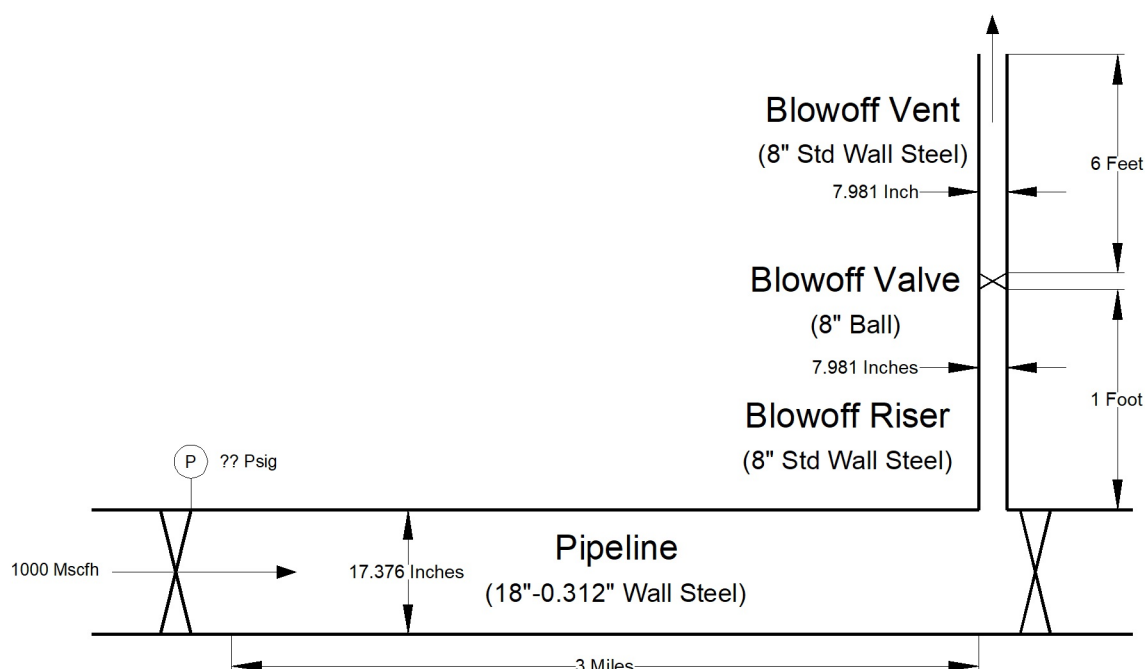
Example 2 - Flow-Controlled Purge

Background

The following example will guide you through the general steps involved in calculating the results associated with a flow-controlled purge configuration. Calculate the time required to purge a pipeline segment containing air, using natural gas, through a main line valve directly upstream of the Pipeline, using a single 6-foot vent of 8" standard wall steel pipe, with an 8-inch ball valve attached to the Pipeline with a 1-foot riser of 8" standard wall steel pipe, at the following conditions.

3 miles - 18-inch 0.312-inch wall pipe
 Inlet Flow Rate = 1000 Mscfh (Controlled)
 Base Pressure = 14.73 psia
 Base Temperature = 60 Fahrenheit
 Atmospheric Pressure = 14.73 psia
 Flowing Temperature = 60 Fahrenheit
 Inlet and Blowoff Efficiency = 0.6

Figure 9 - Example 2



Data Entry

This example illustrates how to enter data and calculate the results for a flow-controlled Pipeline purge. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex2**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today's Date** in your preferred format.
 - For *Notes*, type **Flow Control Example**.
 - Click the *Next* command button.
- On the Configuration step:
 - For *Purge Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Typical US Natural Gas” option is selected.

- For *Pipeline Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Air” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Flow**.
 - For *Inlet Flow Rate*, enter **1000 Mscfh**.
 - For *Base Pressure*, enter **14.73 Psia**.

- For *Base Temperature*, enter **60 Fahrenheit**.
- For *Local Atmospheric Pressure*, enter **14.73 Psia**.
- For *Plot Time Interval*, enter **1 Seconds**.
- For *Maximum Time Duration*, enter **10 Minutes**.
- Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **No**.
 - Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, click the *Select* command button.
 - On the Pipe Selection page:
 - For *Material Type*, select **Steel**.
 - For *Nominal Size*, select **18**.
 - For *Wall Thickness*, select **0.312**.
 - The *Inside Diameter* value is **17.376 Inches**.
 - Click the *Apply* command button.
 - The *Wall Roughness* value is **0.0007 Inches**. (This value is automatically entered when the “Steel” material type is selected on the Pipe Selection page.)
 - For *Length*, enter **3 Miles**.
 - For *Hydraulic Efficiency*, enter **1.0**.
 - For *Flowing Temperature*, enter **60 Fahrenheit**.
 - For *Number Of Displacements*, select **2**.
 - For *Number Of Segments*, select **Auto**.
 - Click the *Next* command button.

- On the Riser step:
 - For *Blowoff Riser*, select **Yes**.
 - For *Inside Diameter*, enter **7.981 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **1 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - For *Riser Fittings*, select **1** next to the *Branch Tee* item.
 - Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Ball**.
 - For *Effective Valve Size*, enter **8 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **7.981 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - Click the *Next* command button.
- On the Review step:
 - Use the scroll bar to review the entered values.

- Revise values by selecting the associated step (step) and changing the value.
- Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.
 - Either save the results, print the results, or edit the calculation input values and calculate again.

Results

The results should be similar to the following:

Arrival Time:	3.02 Minutes
Purge Time:	6.23 Minutes
Mean Velocity:	87.48 Feet/sec
Minimum Interface Velocity:	80.63 Feet/sec
Minimum Allowable Velocity:	3.55 Feet/sec
Mixed Zone Length:	549 Feet
Purge Gas Used:	103327 sCf
Minimum Slug Volume:	1360 sCf
Natural Gas Vented:	26764 sCf
Segment Count:	16

Conclusion & Comments

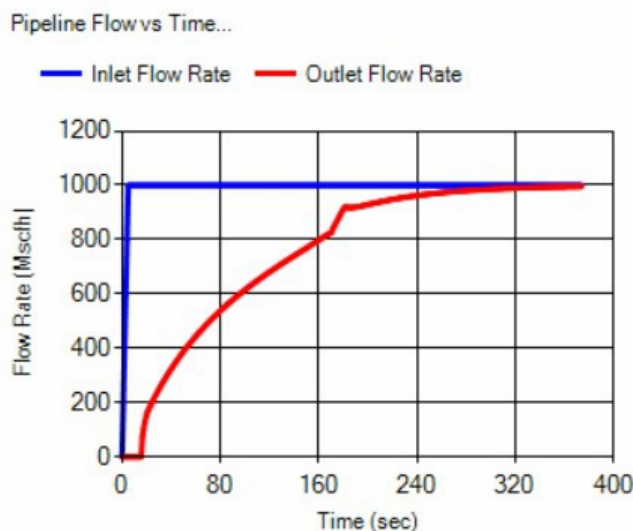
This purge configuration appears to have worked successfully.

Result Values

- The gas-to-gas interface arrived at the end of the Pipeline about 3 minutes after the purge process began. It took about 6 minutes for a volume equal to two displacements (two Pipeline volumes) to be vented. This is the total time to complete the purge, not in addition to the Arrival Time.
- The Minimum Interface Velocity is about 81 feet/sec. The Minimum Allowable Velocity is about 4 feet/sec. This indicates that the velocity at the gas-to-gas interface should be sufficient to limit mixing and prevent stratification of the gases.

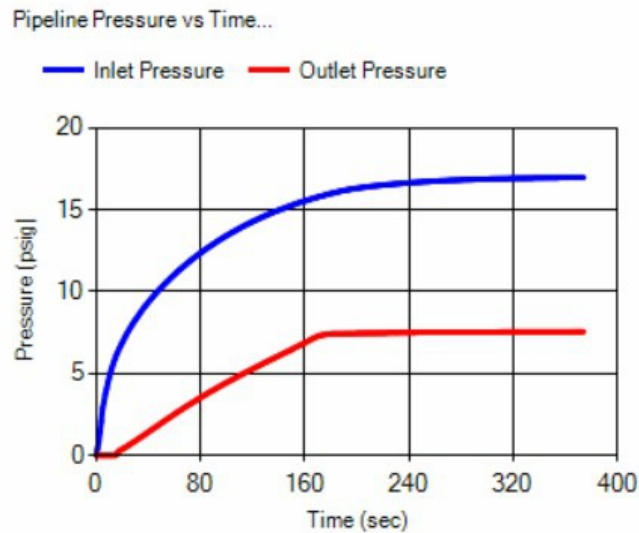
- The Mixed Zone Length is about 550 feet which means that up to about 275 feet on either side of the theoretic gas-to-gas interface location, there could be mixing of the Purge Gas and Pipeline Gas. To offset the Mixed Zone, at least 1360 sCf (the Slug Volume) of Nitrogen would need to be injected before starting the purge.
- A total of about 104 Mscf (103327 sCf) of Natural Gas was introduced into the Pipeline during the purge operation. Of that, a total of about 27 Mscf (26764 sCf) of Natural Gas was vented during the purge operation. This amount includes the volume of gas contained in the Mixed Zone (one-half the Mixed Zone volume) and the gas resulting from extending the Purge Time to two displacements.
- Because the “Auto” option was selected for the Pipeline Number Of Segments, the Pipeline was divided into 16 “calculation” segments during the calculation.

Pipeline Flow vs Time Graphic Results



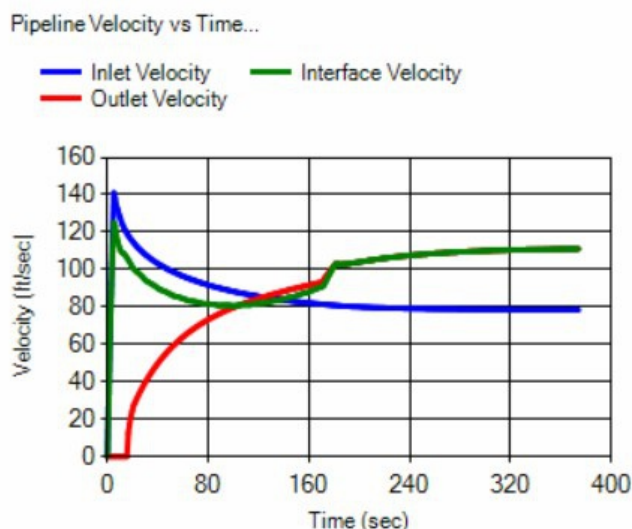
- Studying the Inlet Flow Rate shown on the Pipeline Flow vs Time graph, the very first few seconds show the “ramp-up” of the flow caused by the approximation of the gradual opening of the inlet valve. The flow eventually peaks, which indicates that the inlet valve is sufficiently open to maintain control of the inlet flow. Then the flow becomes steady at the “controlled” value. The Inlet and Outlet Flow Rates will eventually reach the same rate, as steady-state conditions are approached.
- Reviewing the Outlet Flow Rate, the Pipeline Flow vs Time graph shows no flow at the Pipeline outlet for about the first 20 seconds. This is because the Pipeline Gas (air in this case) has not yet started moving at the outlet end of the Pipeline. Eventually, the “pressure wave” will reach the Pipeline end, and air will start flowing out of the vent. Beyond this point, the Outlet Flow Rate gradually increases as the Pipeline pressure increases, creating a higher pressure differential between the Pipeline and the vent outlet, thus increasing the flow rate.
- Around 170 seconds, the Outlet Flow Rate begins to show a slight hook upwards as the gas-to-gas interface and Mixed Zone approach the end of the Pipeline and the Blowoff Assembly.
- When all of the Purge Gas has reached the outlet end of the Pipeline, the properties gradually become completely associated with the Purge Gas, and the Inlet and Outlet Flow Rates converge to a steady-state value.

Pipeline Pressure vs Time Graphic Results



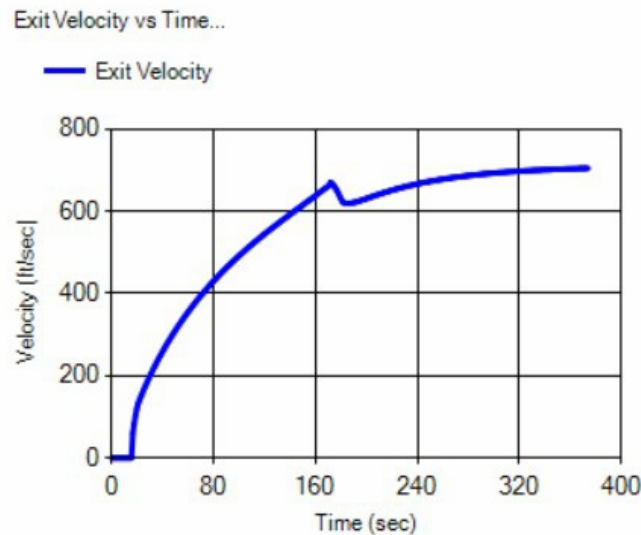
- Reviewing the Outlet Pressure, the Pipeline Pressure vs Time graph shows no pressure increase at the Pipeline outlet for about the first 20 seconds. This is because the “pressure wave” has not yet reached the end of the Pipeline. Beyond this point, the Outlet Pressure gradually increases until all of the Pipeline Gas has been vented and the pressures and flows reach steady-state conditions.
- The Inlet Pressure gradually increases from the start of the purge until the Inlet and Outlet Flow Rates converge to steady-state values. This occurs because, for a time, the Inlet Flow Rate is higher than the Outlet Flow Rate, and gas (in this case) is filling the Pipeline, increasing its pressure.

Pipeline Velocity vs Time Graphic Results



- There are three values depicted on the Pipeline Velocity vs. Time graph - Inlet, Outlet, and Interface Velocities.
- As in the flow and pressure cases, the Outlet Velocity does not begin to increase until the “pressure wave” reaches the end of the Pipeline. The increase in velocity coincides with the time when the air begins to flow out of the vent. Beyond this point, the Outlet Velocity gradually increases until all of the Pipeline Gas has been vented and the pressures and flows approach steady-state conditions.
- Around 170 seconds, the Outlet Velocity starts to show a slight hook upward as the gas-to-gas interface approaches the Pipeline end, similar to what happens with the Outlet Flow Rate.
- The Inlet Velocity increases rapidly for the first few seconds, then begins to decrease as pressure in the Pipeline increases. Eventually reaching a steady value as the pressures and flows approach a steady state.
- The Interface Velocity tracks the Inlet Velocity until about the time that the Inlet and Outlet Velocities intersect. The Interface Velocity then begins to increase until the Pipeline Gas (air) has been completely vented, where it then becomes the same as the Outlet Velocity.

Exit Velocity vs Time Graphic Results



- The shape of the Exit Velocity curve is similar to that of the Outlet Velocity, but the magnitude of the Exit Velocity is much higher.
- The Pipeline Gas is air, so no combustible gas is present at the vent exit until the Mixed Zone arrives at about the 170-second mark. After that time, the Exit Velocity is well above the flame speed of the Purge Gas (natural gas), indicating that if ignition occurred, it would not be possible for a flame to enter the vent.
- The Exit Velocity does not reach sonic velocity, so the flow in the vent is not choked.
- The Exit Velocity is in excess of 200 feet per second for most of the purge duration. If limiting noise at the vent location were important in this scenario, measures would need to be taken to reduce the Exit Velocity and/or to mitigate the noise.

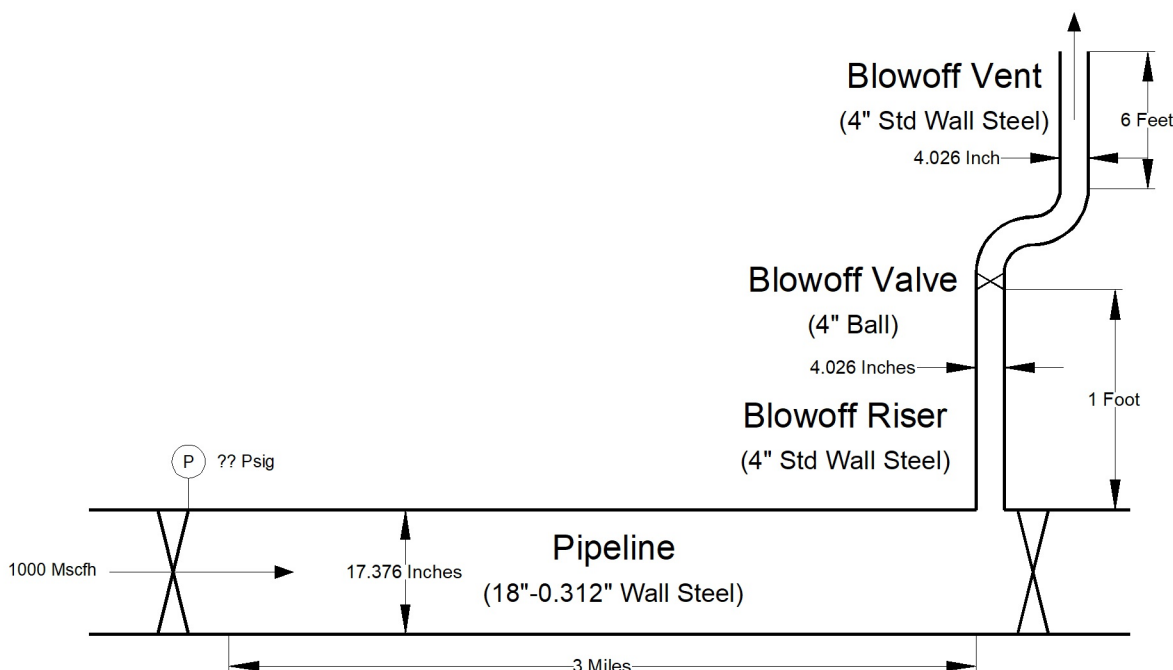
Example 3 - Pressure-Controlled Purge - Fittings & Reduced Valve

Background

For this example, we will use the configuration in Example 2; however, in the Blowoff Assembly, we will use a 4-inch vent with a valve whose Effective Valve Size is also 4 inches, along with a couple of long-radius 90-degree elbows in the Vent.

3 miles - 18-inch 0.312-inch wall pipe
 Inlet Flow Rate = 1000 Mscfh (Controlled)
 Base Pressure = 14.73 psia
 Base Temperature = 60 Fahrenheit
 Atmospheric Pressure = 14.73 psia
 Flowing Temperature = 60 Fahrenheit
 Inlet and Blowoff Efficiency = 0.6

Figure 10 - Example 3



Data Entry

This example illustrates how to enter data and calculate the results for a Pipeline purge with fittings included in the Blowoff Vent. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex3**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today's Date** in your preferred format.
 - For *Notes*, type **Flow Control Example With 4" Vent**.
 - Click the *Next* command button.
- On the Configuration step:
 - For *Purge Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Typical US Natural Gas” option is selected.

- For *Pipeline Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Air” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Flow**.
 - For *Inlet Flow Rate*, enter **1000 Mscfh**.
 - For *Base Pressure*, enter **14.73 Psia**.

- For *Base Temperature*, enter **60 Fahrenheit**.
- For *Local Atmospheric Pressure*, enter **14.73 Psia**.
- For *Plot Time Interval*, enter **1 Seconds**.
- For *Maximum Time Duration*, enter **20 Minutes**.
- Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **No**.
 - Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, click the *Select* command button.
 - On the Pipe Selection page:
 - For *Material Type*, select **Steel**.
 - For *Nominal Size*, select **18**.
 - For *Wall Thickness*, select **0.312**.
 - The *Inside Diameter* value is **17.376 Inches**.
 - Click the *Apply* command button.
 - The *Wall Roughness* value is **0.0007 Inches**. (This value is automatically entered when the “Steel” material type is selected on the Pipe Selection page.)
 - For *Length*, enter **3 Miles**.
 - For *Hydraulic Efficiency*, enter **1.0**.
 - For *Flowing Temperature*, enter **60 Fahrenheit**.
 - For *Number Of Displacements*, select **2**.
 - For *Number Of Segments*, select **Auto**.
 - Click the *Next* command button.

- On the Riser step:
 - For *Blowoff Riser*, select **Yes**.
 - For *Inside Diameter*, enter **4.026 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **1 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - For *Riser Fittings*, select **1** for *Branch Tee*.
 - Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Ball**.
 - For *Effective Valve Size*, enter **4 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **4.026 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - In the *Vent Fittings* list, select **2** for *Elbow 90 LR*.
 - Click the *Next* command button.

- On the Review step:
 - Use the scroll bar to review the entered values.
 - Revise values by selecting the associated step (step) and changing the value.
 - Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.
 - Either save the results, print the results, or edit the calculation input values and calculate again.

Results

You should receive a warning that the flow in the Blowoff Vent is “choked”. Choked flow does not necessarily indicate an error; it simply indicates that the flow velocity has reached sonic velocity in the vent, thereby limiting the flow rate through the vent and increasing the Arrival and Purge Times.

The results should be similar to the following:

***** Warning: Choked Flow In Blowoff Vent**

Arrival Time:	5.80 Minutes
Purge Time:	10.72 Minutes
Mean Velocity:	45.55 Feet/sec
Minimum Interface Velocity:	23.45 Feet/sec
Minimum Allowable Velocity:	3.55 Feet/sec
Mixed Zone Length:	412 Feet
Purge Gas Used:	178168 sCf
Minimum Slug Volume:	2147 sCf
Natural Gas Vented:	27158 sCf
Segment Count:	16

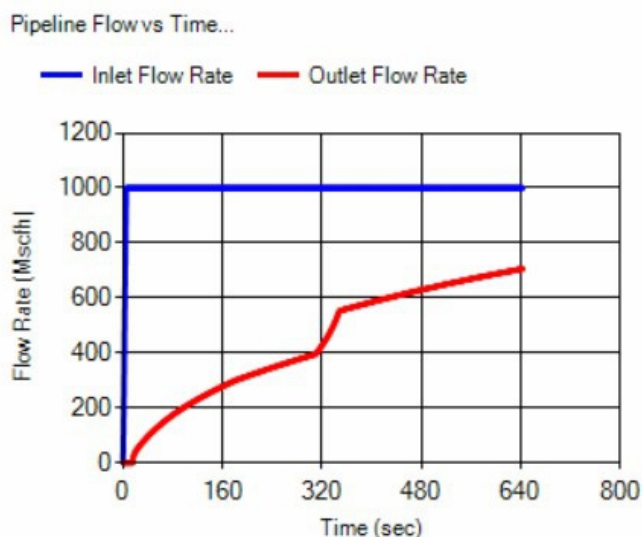
Conclusion & Comments

This purge configuration appears to have worked successfully.

Result Values

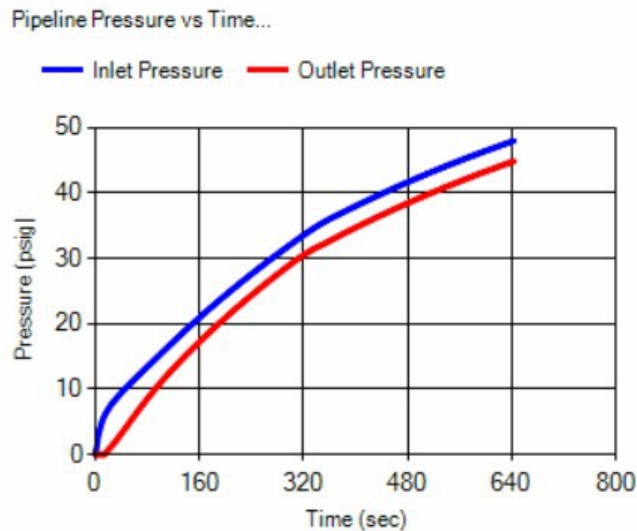
- The gas-to-gas interface arrived at the end of the Pipeline about 6 minutes after the purge process began. It took about 11 minutes for a volume equal to two displacements (two Pipeline volumes) to be vented. These times are longer than the time for Example 2 due to the reduced size of the vent section, which restricts the outlet flow.
- The Minimum Interface Velocity is about 23.5 feet/sec. The Minimum Allowable Velocity is about 4 feet/sec. This indicates that the velocity at the gas-to-gas interface should be sufficient to prevent mixing and avoid stratification of the gases.
- The Mixed Zone Length is about 400 feet, which means that up to about 200 feet on either side of the theoretical gas-to-gas interface location, there could be mixing of the Purge Gas and Pipeline Gas. To offset the Mixed Zone, at least 2147 sCf (the Slug Volume) of Nitrogen would need to be injected before starting the purge.
- A total of about 179 Mscf (178168 sCf) of Natural Gas was introduced into the Pipeline during the purge operation. Of that, a total of about 27 Mscf of Natural Gas was vented during the purge operation. This amount includes the volume of gas contained in the Mixed Zone (one-half the Mixed Zone volume) and the gas resulting from extending the Purge Time to two displacements.
- Because the “Auto” option was selected for the Pipeline Number Of Segments, the Pipeline was divided into 16 “calculation” segments during the calculation.

Pipeline Flow vs Time Graphic Results



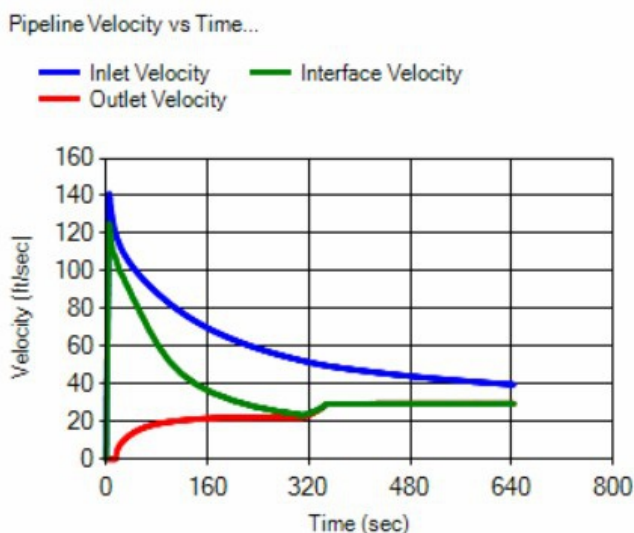
- Studying the Inlet Flow Rate shown on the Pipeline Flow vs Time graph, the very first few seconds show the “ramp-up” of the flow caused by the approximation of the gradual opening of the inlet valve. The flow eventually reaches the “controlled” flow rate. In this case, the Inlet and Outlet Flow Rates never reach the same rate. Steady-state conditions are not reached during the Purge Time. The smaller Blowoff Valve and Vent (4 inches vs 8 inches) causes the Outlet Flow Rate to be reduced compared to the rates found in Example 2.
- Reviewing the Outlet Flow Rate, the Pipeline Flow vs Time graph shows no flow at the beginning of the purge process. This is because the Pipeline Gas (air in this case) has not yet started moving at the outlet end of the Pipeline. Eventually, the “pressure wave” will reach the Pipeline end, and air will start flowing out of the vent. Beyond this point, the outlet flow gradually increases as the Pipeline pressure increases, creating a higher pressure differential between the Pipeline and the vent outlet, thus increasing the flow rate.
- At around 320 seconds, a slight hook upward in the Outlet Flow Rate begins to appear as the gas-to-gas interface and Mixed Zone approach the Pipeline end and the Blowoff Assembly.
- When all of the Purge Gas has reached the outlet end of the Pipeline, the properties gradually become completely associated with the Purge Gas. If the Purge Time were extended, the flows would eventually reach a steady-state value.

Pipeline Pressure vs Time Graphic Results



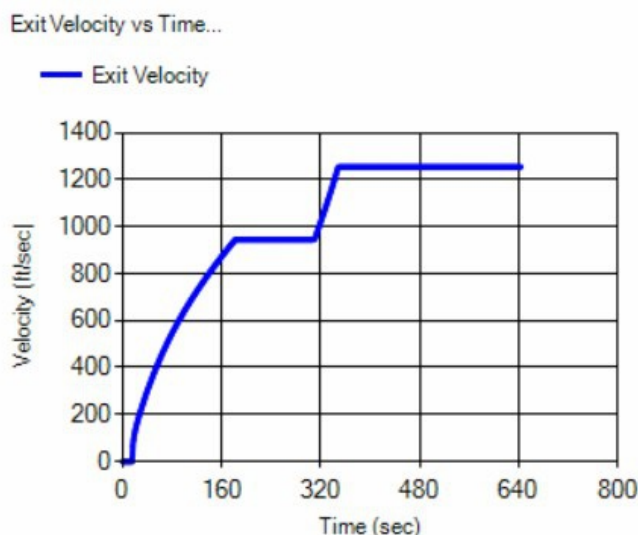
- Reviewing the Outlet Pressure, the Pipeline Pressure vs Time graph shows no pressure increase at the Pipeline outlet at the beginning of the purge process. This is because the “pressure wave” has not yet reached the end of the Pipeline. Beyond this point, the Outlet Pressure gradually increases until all of the Pipeline Gas has been vented. The Inlet and Outlet Pressures will continue to change until steady-state conditions are reached (some time beyond the Purge Time).

Pipeline Velocity vs Time Graphic Results



- There are three values depicted on the Pipeline Velocity vs Time graph - Inlet, Outlet, and Interface Velocities.
- As in the Flow Rate and Pressure cases, the Outlet Velocity does not begin to increase until the “pressure wave” reaches the end of the Pipeline. The increase in velocity coincides with the time when the air begins to flow out of the Vent. Beyond this point, the Outlet Velocity begins to increase until “choked” flow occurs in the Vent. From that point on, the velocity remains steady until the Mixed Zone reaches the Pipeline outlet end. It then begins to increase due to the changing gas properties until the Mixed Zone has been vented. From then on, only Purge Gas is being vented, and the flow remains steady again, because of the choked flow in the Vent.
- The Inlet Velocity increases rapidly for the first few seconds, then begins to gradually decrease as the pressure in the Pipeline increases.
- The Interface Velocity tracks the Inlet Velocity until about the time that the Mixed Zone begins to reach the Pipeline outlet. Beyond that point, the Interface Velocity is really not applicable and is shown the same as the Outlet Velocity.

Exit Velocity vs Time Graphic Results



- The Pipeline Gas is air, so no combustible gas is present at the vent exit until the Mixed Zone arrives at about the 320-second mark. After that time, the Exit Velocity is well above the flame speed of the Purge Gas (natural gas), indicating that if ignition occurred, it would not be possible for a flame to enter the vent.
- The Exit Velocity reaches the sonic velocity of the Pipeline Gas at about the 180-second mark. When this occurs, the flow at the vent is considered to be “choked”. Velocity at the vent exit remains steady until the Mixed Zone arrives at the vent. The changing gas properties during the transition from Pipeline Gas to Purge Gas cause the Exit Velocity to increase. After the Mixed Zone is vented, only the Purge Gas remains, and the vent velocity again remains steady at the sonic velocity of the Purge Gas.
- The Exit Velocity is in excess of 200 feet per second for most of the purge duration. If limiting noise at the vent location were important in this scenario, measures would need to be taken to reduce the Exit Velocity and/or to mitigate the noise.

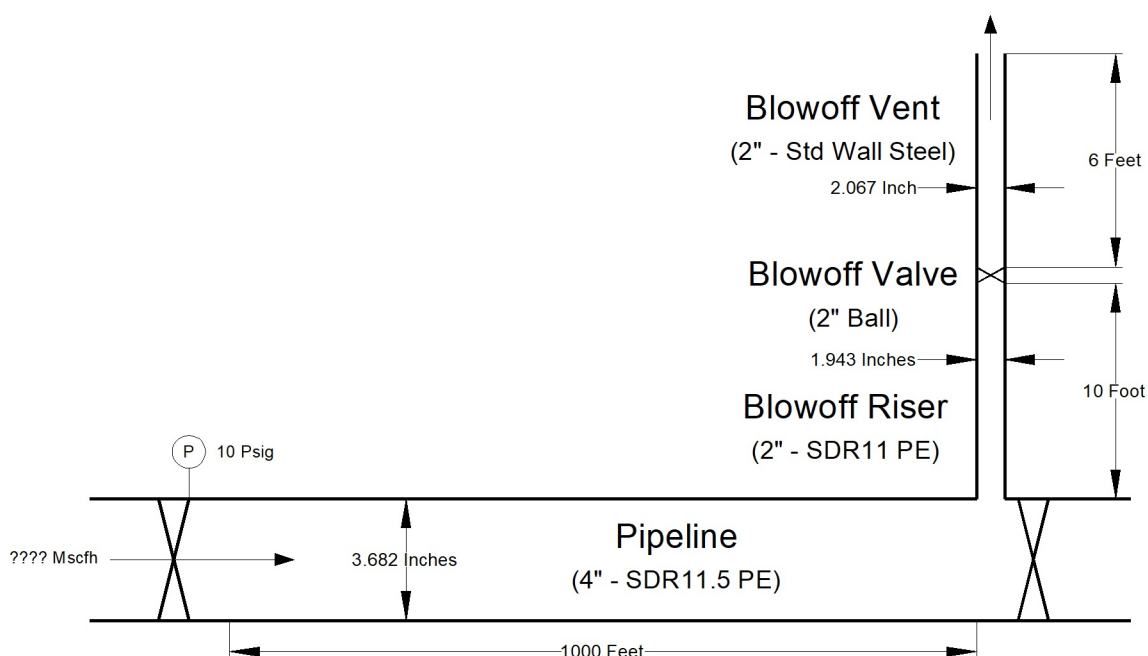
Example 4 - Pressure-Controlled Purge - No Inlet Segment

Background

The following example will guide you through the steps involved in calculating the results associated with a pressure-controlled purge configuration using no Inlet Pipe. Calculate the time required to purge a pipeline containing air, using natural gas, through a main line valve or “squeeze-off” directly upstream of the Pipeline, using a 10-foot long service with a 2-inch ball valve and a 2-inch steel vent attached to the end of the service riser to vent the gas, at the following conditions.

1000 feet - 4-inch SDR 11.5 Polyethylene pipe
 Inlet Pressure = 10 psig (Controlled)
 Base Pressure = 14.73 psia
 Base Temperature = 60 Fahrenheit
 Atmospheric Pressure = 14.73 psia
 Flowing Temperature = 60 Fahrenheit
 Blowoff Efficiency = 0.6

Figure 11 - Example 4



Data Entry

This example illustrates how to enter data and calculate the results for a pressure controlled Pipeline purge as described below. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex4**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today's Date** in your preferred format.
 - For *Notes*, type **Pressure Control Example With No Inlet Pipe**.
 - Click the *Next* command button.
- On the Configuration step:
 - For *Purge Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Typical US Natural Gas” option is selected.

- For *Pipeline Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Air” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Pressure**.
 - For *Inlet Pressure*, enter **10 Psig**.
 - For *Base Pressure*, enter **14.73 Psia**.

- For *Base Temperature*, enter **60 Fahrenheit**.
- For *Local Atmospheric Pressure*, enter **14.73 Psia**.
- For *Plot Time Interval*, enter **1 Seconds**.
- For *Maximum Time Duration*, enter **100 Seconds**.
- Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **No**.
 - Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, click the *Select* command button.
 - On the Pipe Selection page:
 - For *Material Type*, select **Plastic - US**.
 - For *Nominal Size*, select **4**.
 - For *SDR*, select **11**.
 - The *Inside Diameter* value is **3.682 Inches**.
 - Click the *Apply* command button.
 - The *Wall Roughness* value is **0.00006 Inches**. (This value is automatically entered when the “Plastic” material type is selected on the Pipe Selection page.)
 - For *Length*, enter **1000 Feet**.
 - For *Hydraulic Efficiency*, enter **1.0**.
 - For *Flowing Temperature*, enter **60 Fahrenheit**.
 - For *Number Of Displacements*, select **2**.
 - For *Number Of Segments*, select **Auto**.
 - Click the *Next* command button.

- On the Riser step:
 - For *Blowoff Riser*, select **Yes**.
 - For *Inside Diameter*, enter **1.943 Inches**.
 - For *Wall Roughness*, enter **0.00006 Inches**.
 - For *Length*, enter **10 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - For *Riser Fittings*, select **1** for *Branch Tee*.
 - Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Ball**.
 - For *Effective Valve Size*, enter **2 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **2.067 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - Click the *Next* command button.
- On the Review step:
 - Use the scroll bar to review the entered values.

- Revise values by selecting the associated step (step) and changing the value.
- Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.
 - Either save the results, print the results, or edit the calculation input values and calculate again.

Results

The results should be similar to the following:

Arrival Time:	11.65 Seconds
Purge Time:	27.43 Seconds
Mean Velocity:	85.85 Feet/sec
Minimum Interface Velocity:	76.87 Feet/sec
Minimum Allowable Velocity:	2.10 Feet/sec
Mixed Zone Length:	62 Feet
Purge Gas Used:	270 sCf
Minimum Slug Volume:	7 sCf
Natural Gas Vented:	77 sCf
Segment Count:	10

Conclusion & Comments

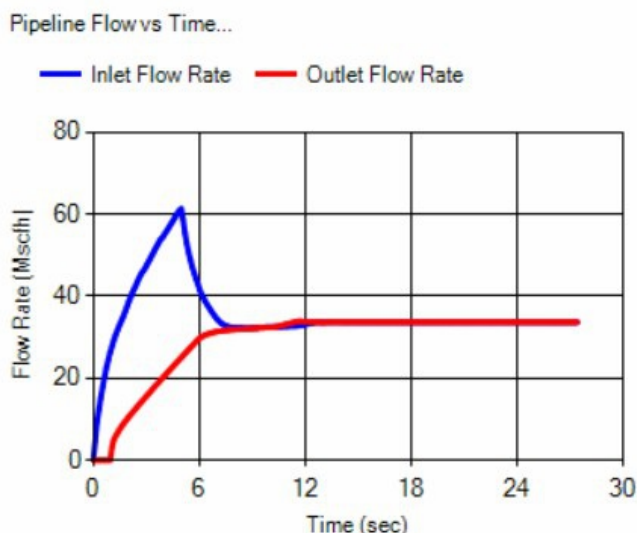
This purge configuration appears to have worked successfully.

Result Values

- The gas-to-gas interface arrived at the end of the Pipeline about 12 seconds after the purge process began. It took about 28 seconds for a volume equal to two displacements (two Pipeline volumes) to be vented. This is the total time to complete the purge, not in addition to the Arrival Time.
- The Minimum Interface Velocity is about 77 feet/sec. The Minimum Allowable Velocity is about 2 feet/sec. This indicates that the velocity at the gas-to-gas interface should be sufficient to limit mixing and to prevent stratification of the gases.

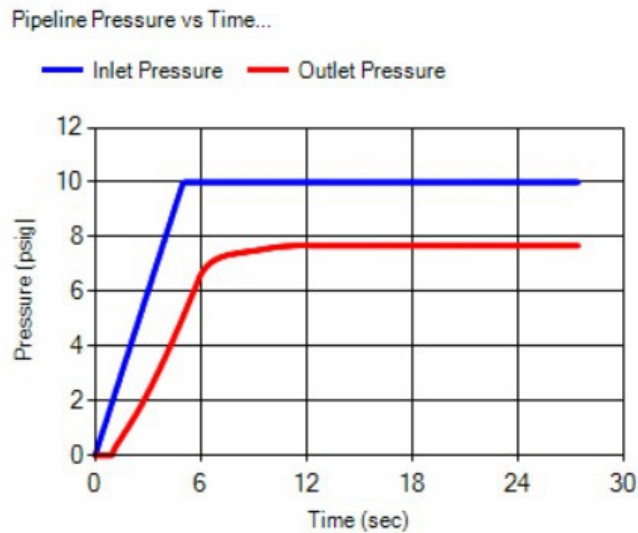
- The Mixed Zone Length is about 60 feet, which means that up to about 30 feet on either side of the theoretical gas-to-gas interface location, there could be mixing of the Purge Gas and Pipeline Gas. To offset the Mixed Zone, at least 7 sCf (the Slug Volume) of Nitrogen would need to be injected before starting the purge.
- A total of about 270 sCf of Natural Gas was introduced into the Pipeline during the purge operation. Of that, a total of about 77 sCf of Natural Gas was vented during the purge operation. This amount includes the volume of gas contained in the Mixed Zone (one-half the Mixed Zone volume) and the gas resulting from extending the Purge Time to two displacements.
- Because the “Auto” option was selected for the Pipeline Number Of Segments, the Pipeline was divided into 10 “calculation” segments during the calculation.

Pipeline Flow vs Time Graphic Results



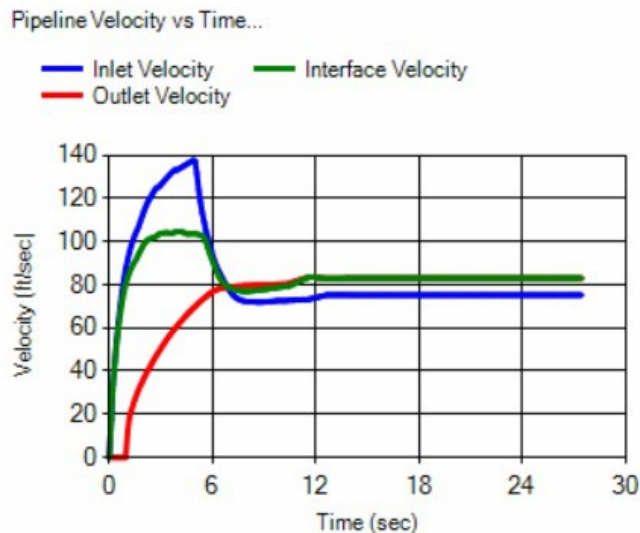
- Studying the Inlet Flow Rate shown on the Pipeline Flow vs Time graph, the very first few seconds show the “ramp-up” of the flow caused by the approximation of the gradual opening of the inlet valve. The flow eventually peaks, representing that the inlet valve is sufficiently open to maintain the Inlet Pressure. Then the flow begins to slow as the Pipeline pressure increases, decreasing the pressure differential near the Pipeline inlet and thus reducing the flow rate. The Inlet and Outlet Flow Rates will eventually reach the same rate as steady-state conditions are reached.
- Reviewing the Outlet Flow Rate, the Pipeline Flow vs Time graph shows no flow at the Pipeline outlet for about the first second. This is because the Pipeline Gas (air in this case) has not yet started moving at the outlet end of the Pipeline. Eventually, the “pressure wave” will reach the Pipeline end, and air will start flowing out of the vent. Beyond this point, the outlet flow gradually increases as the Pipeline pressure increases, creating a higher pressure differential between the Pipeline and the vent outlet, thus increasing the flow rate.
- When all of the Purge Gas has reached the outlet end of the Pipeline, the properties gradually become completely associated with the Purge Gas, and the Inlet and Outlet Flow Rates converge to a steady-state value.

Pipeline Pressure vs Time Graphic Results



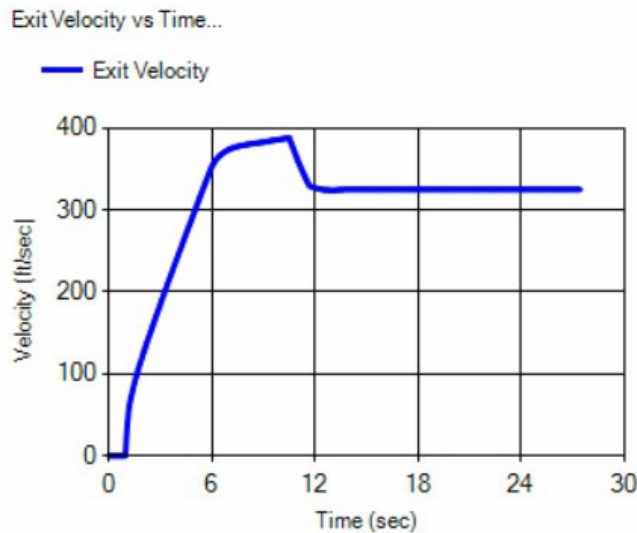
- Reviewing the Outlet Pressure, the Pipeline Pressure vs Time graph shows no pressure increase at the Pipeline outlet for about the first second. This is because the “pressure wave” has not yet reached the end of the Pipeline. Beyond this point, the Outlet Pressure gradually increases until all of the Pipeline Gas has been vented and the pressures and flows reach steady-state conditions.
- The Inlet Pressure rapidly increases at the start of the purge until the “controlled” pressure value is reached. It then remains at the controlled pressure value until the purge is complete.

Pipeline Velocity vs Time Graphic Results



- There are three values depicted on the Pipeline Velocity vs Time graph - Inlet, Outlet, and Interface Velocities.
- As in the Flow Rate and Pressure cases, the Outlet Velocity does not begin to increase until the “pressure wave” reaches the end of the Pipeline. The increase in velocity coincides with the time when the air begins to flow out of the vent. Beyond this point, the Outlet Velocity gradually increases until all of the Pipeline Gas has been vented and the pressures and flow rates reach steady-state conditions.
- The Inlet Velocity increases rapidly for the first few seconds, then begins to decrease as the pressure in the Pipeline increases. Eventually reaching a steady value as the pressures and flows reach a steady-state.
- The Interface Velocity tracks the Inlet Velocity until about the time that the Inlet and Outlet Velocities intersect. The Interface Velocity then begins to increase until the Pipeline Gas (air) has been completely vented, where it then becomes the same as the Outlet Velocity.

Exit Velocity vs Time Graphic Results



- The Exit Velocity increases steadily for the first few seconds, then levels off as the Mixed Zone begins to exit through the vent. Once the Pipeline Gas is completely vented, the Exit Velocity decreases until the flow reaches steady-state conditions. The Exit Velocity is well in excess of the flame speed by the time the combustible gas (the Purge Gas) reaches the vent exit, indicating that if ignition occurred, it would not be possible for a flame to enter the vent.
- The Exit Velocity does not reach sonic velocity, so the flow in the vent is not choked.
- The Exit Velocity is in excess of 200 feet per second for most of the purge duration. If limiting noise at the vent location were important in this scenario, measures would need to be taken to reduce the Exit Velocity and/or to mitigate the noise.

Example 5 - Pressure-Controlled Purge - No Inlet Segment - LP

Background

The following example will guide you through the steps involved in calculating the results associated with a pressure-controlled purge configuration using no Inlet Pipe, with low-pressure Purge Gas. Calculate the time required to purge a pipeline segment containing air, using natural gas, through a main line valve or “stopper” directly upstream of the Pipeline, using a 30 foot long 4" service with a 4-inch ball valve and 4-inch steel vent attached to the end of the riser to vent the gas, at the following conditions.

1000 feet - 12-inch - 0.560 inch Wall Thickness Cast Iron pipe

(12.080 inch Inside Diameter)

Inlet Pressure = 1.0 psig (Controlled)

Base Pressure = 14.73 psia

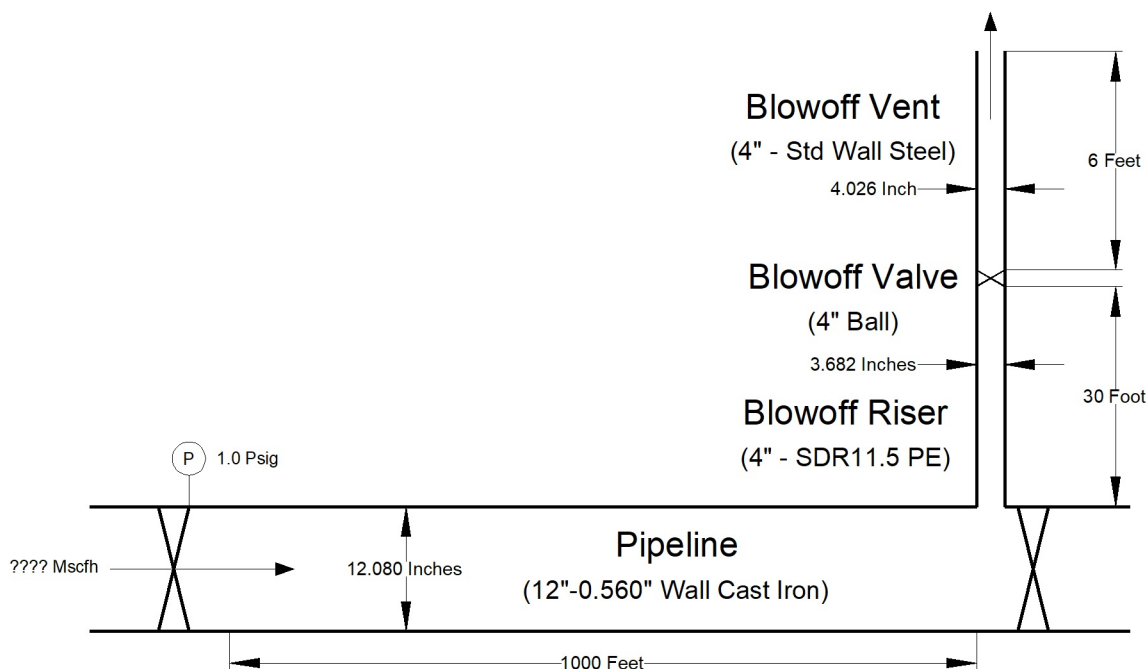
Base Temperature = 60 Fahrenheit

Atmospheric Pressure = 14.73 psia

Flowing Temperature = 60 Fahrenheit

Blowoff Efficiency = 0.6

Figure 12 - Example 5



Data Entry

This example illustrates how to enter data and calculate the results for a pressure controlled Pipeline purge as described below. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex5**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today's Date** in your preferred format.
 - For *Notes*, type **Pressure Control Example With No Inlet Pipe Low Pressure**.
 - Click the *Next* command button.
- On the Configuration step:
 - For *Purge Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Typical US Natural Gas” option is selected.

- For *Pipeline Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Air” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Pressure**.
 - For *Inlet Pressure*, enter **1.0 Psig**.
 - For *Base Pressure*, enter **14.73 Psia**.

- For *Base Temperature*, enter **60 Fahrenheit**.
- For *Local Atmospheric Pressure*, enter **14.73 Psia**.
- For *Plot Time Interval*, enter **1 Seconds**.
- For *Maximum Time Duration*, enter **10 Minutes**.
- Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **No**.
 - Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, enter **12.08 Inches**.
 - For *Wall Roughness*, enter **0.0102 Inches**.
 - For *Length*, enter **1000 Feet**.
 - For *Hydraulic Efficiency*, enter **1.0**.
 - For *Flowing Temperature*, enter **60 Fahrenheit**.
 - For *Number Of Displacements*, select **2**.
 - For *Number Of Segments*, select **Auto**.
 - Click the *Next* command button.
- On the Riser step:
 - For *Blowoff Riser*, select **Yes**.
 - For *Inside Diameter*, enter **3.682 Inches**.
 - For *Wall Roughness*, enter **0.00006 Inches**.
 - For *Length*, enter **30 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.

- For *Riser Fittings*, select **1** for *Elbow 90 LR* (to account for the riser elbow).
- For *Riser Fittings*, select **1** for *Branch Tee*.
- Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Ball**.
 - For *Effective Valve Size*, enter **4 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **4.026 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.6**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - Click the *Next* command button.
- On the Review step:
 - Use the scroll bar to review the entered values.
 - Revise values by selecting the associated step (step) and changing the value.
 - Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.

- Either save the results, print the results, or edit the calculation input values and calculate again.

Results

The results should be similar to the following:

Arrival Time:	2.90 Minutes
Purge Time:	8.71 Minutes
Mean Velocity:	5.75 Feet/sec
Minimum Interface Velocity:	4.72 Feet/sec
Minimum Allowable Velocity:	2.96 Feet/sec
Mixed Zone Length:	137 Feet
Purge Gas Used:	2442 sCf
Minimum Slug Volume:	116 sCf
Natural Gas Vented:	854 sCf
Segment Count:	10

Conclusion & Comments

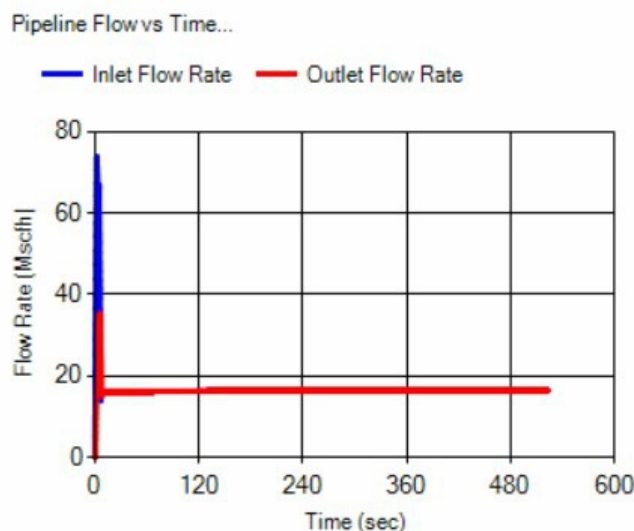
This purge configuration appears to have worked successfully.

Result Values

- The gas-to-gas interface arrived at the end of the Pipeline about 3 minutes after the purge process began. It took about 9 minutes for a volume equal to two displacements (two Pipeline volumes) to be vented. This is the total time to complete the purge, not in addition to the Arrival Time.
- The Minimum Interface Velocity is about 6 feet/sec. The Minimum Allowable Velocity is about 3 feet/sec. This indicates that the velocity at the gas-to-gas interface should be sufficient to limit mixing and to prevent stratification of the gases.
- The Mixed Zone Length is about 140 feet, which means that up to about 70 feet on either side of the theoretical gas-to-gas interface location, there could be mixing of the Purge Gas and Pipeline Gas. To offset the Mixed Zone, at least 116 sCf (the Slug Volume) of Nitrogen would need to be injected before starting the purge.

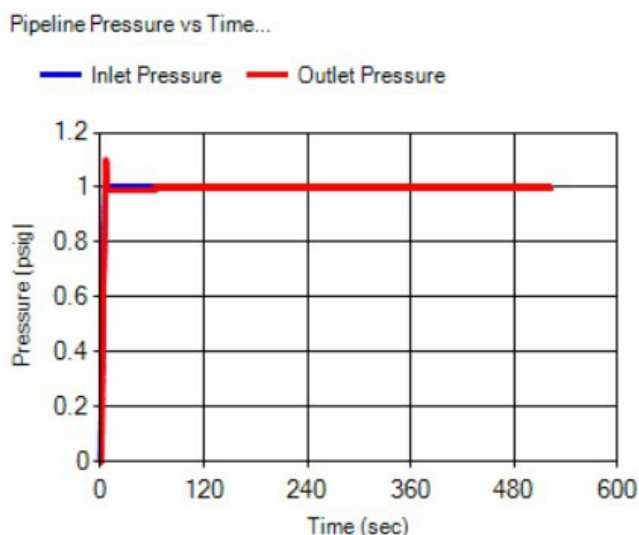
- A total of about 2400 scf of Natural Gas was introduced into the Pipeline during the purge operation. Of that, a total of about 850 sCf of Natural Gas was vented during the purge operation. This amount includes the volume of gas contained in the Mixed Zone (one-half the Mixed Zone volume) and the gas resulting from extending the Purge Time to two displacements.
- Because the “Auto” option was selected for the Pipeline Number Of Segments, during the calculation, the Pipeline was divided into 10 “calculation” segments.

Pipeline Flow vs Time Graphic Results



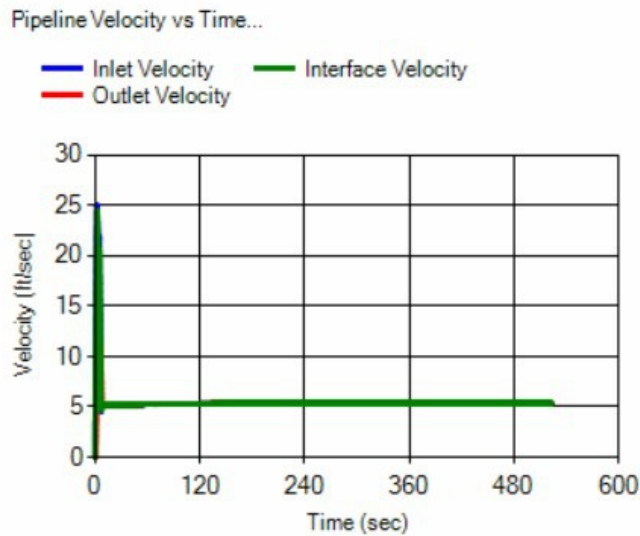
- Studying the Inlet Flow Rate shown on the Pipeline Flow vs Time graph, the very first few seconds show the “ramp-up” of the flow caused by the approximation of the gradual opening of the inlet valve. The flow quickly peaks, representing that the inlet valve is sufficiently open to maintain the Inlet Pressure. Then the flow quickly slows as the Pipeline pressure increases, decreasing the pressure differential near the Pipeline inlet and thus reducing the flow rate. In this case, the Inlet and Outlet Flow Rates quickly reach the same rate, as steady-state conditions are reached.
- Reviewing the Outlet Flow Rate, the Pipeline Flow vs Time graph shows that the flow quickly increases, then settles down to essentially the same as the Inlet Flow Rate.
- The flow changes quickly in this example for a couple of reasons; the Pipeline is relatively short, and the vent diameter is relatively small compared to the inlet (the Pipeline inlet). Both of these conditions enable the Pipeline to pressurize quickly and reach steady-state conditions rapidly.

Pipeline Pressure vs Time Graphic Results



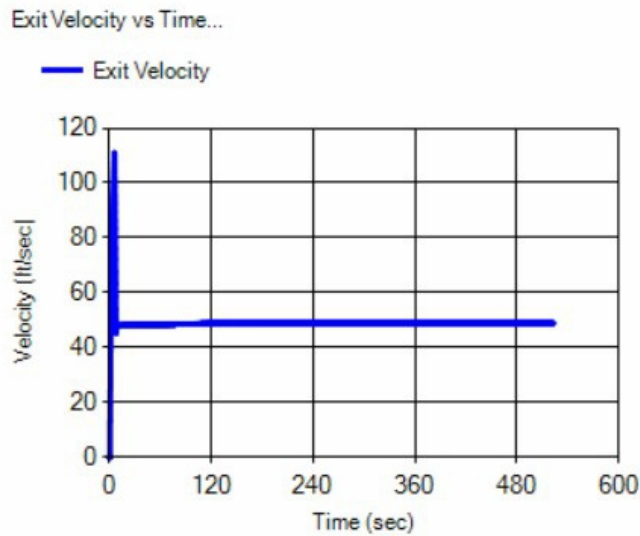
- Reviewing the Outlet Pressure, the Pipeline Pressure vs Time graph shows a somewhat quick pressure increase, in fact, a “surge”, at the Pipeline outlet, all occurring in the first few seconds. Beyond this point, the Outlet Pressure stabilizes to a value similar to the Inlet Pressure as the pressures and flow rates reach steady-state conditions.
- The Inlet Pressure rapidly increases at the start of the purge until the “controlled” pressure value is reached. It then remains at the controlled pressure value until the purge is complete.
- In this example, the Pipeline pressurizes quickly due to the relatively short Pipeline length and small Blowoff Assembly size compared to the Pipeline size. These conditions allow the “pressure wave” to quickly reach the end of the Pipeline and begin increasing the Pipeline pressure.

Pipeline Velocity vs Time Graphic Results



- There are three values depicted on the Pipeline Velocity vs Time graph - Inlet, Outlet, and Interface Velocities.
- As in the flow and pressure cases, the Outlet Velocity quickly spikes then settles down to a relatively steady value. The other velocities follow a similar pattern, again because of the short Pipeline length and small Blowoff Assembly.

Exit Velocity vs Time Graphic Results



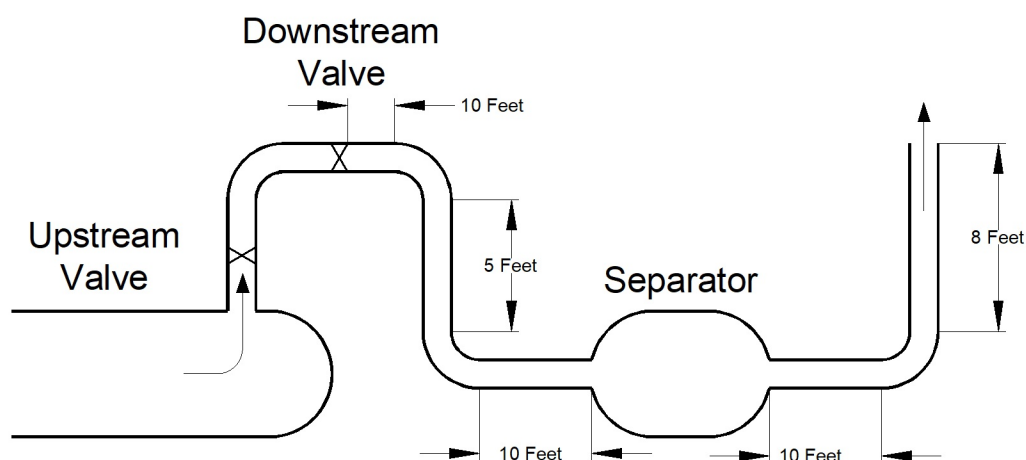
- As with the other velocities, the Exit Velocity quickly spikes and then settles down to a relatively steady value that is in excess of the flame speed of the Purge Gas, indicating that if ignition occurred, it would not be possible for a flame to enter the vent.
- The Exit Velocity does not reach sonic velocity, so the flow in the vent is not choked.
- The Exit Velocity is well under 200 feet per second for all of the purge duration, and under 100 feet per second for most of the duration. Noise should not be an issue in this case.

Example 6 - Handling Unique Fittings

Background

Some purges are conducted using specialized equipment that may include separators, silencers, odorizers, and various other equipment pieces. To correctly model these components requires knowledge of the pressure drop in these components.

Figure 13 - Example 6



This example illustrates how to incorporate one of these fittings into the purge calculation by utilizing its equivalent length value. Figure 13 shows a Blowoff Assembly that includes a separator. A 6-inch Schedule 80 pipe is used for the Blowoff Vent piping, with an *Inside Diameter* of 5.761 inches. The Blowoff Valve has an effective size of 5 inches. The separator has a flow resistance coefficient ($K_{\text{separator}}$) of 1.4 based on the blowoff pipe diameter of 5.761 inches. To include the separator in the pressure calculations, its equivalent length needs to be calculated. Using a fully turbulent friction factor (f_t) of 0.015, the equivalent length, in pipe diameters, is calculated as follows:

$$\left(\frac{L_e}{D}\right)_{separator} = \frac{K_{separator}}{f_t} = \frac{1.4}{0.015} = 93.3$$

The resulting value of 93.3 can now be entered for the Le/D value in the *Miscellaneous* item on the Fittings page. To access the Fittings page, either select *Fittings* from the *Project* menu or click the *Fitting Equivalent Lengths* command button on the Parameters step.

To include the separator in the Blowoff Vent, select “1” for the *Miscellaneous* item in the *Vent Fittings* list. Assuming that the Blowoff Vent piping starts at the most downstream valve in the Blowoff Assembly, enter “43 Feet” (the sum of all of the pipe sections in the Blowoff Vent), and select appropriate quantities for the other fitting types. Identify the most downstream valve as the Blowoff Valve. Include the valve and elbow upstream of the Blowoff Valve in the Blowoff Riser fittings.

[Project](#)
[Configuration](#)
[Parameters](#)
[Inlet](#)
[Pipeline](#)
[Riser](#)
[Valve](#)
[Vent](#)
[Review](#)
[Results](#)

Previous

Next

Blowoff Vent:
☒ Yes ☐ No

Inside Diameter:

Select

5.761

Inches ▾

Wall Roughness:

0.0007

 Inches

Length:

43

Feet ▾

Hydraulic Efficiency:

0.6

Vent Fittings:

Fitting	Quantity
Elbow 90 SR	<div>0 ▾</div>
Elbow 90 LR	<div>0 ▾</div>
Elbow 45	<div>0 ▾</div>
Run Tee	<div>0 ▾</div>
Branch Tee	<div>0 ▾</div>
Ball Valve	<div>0 ▾</div>
Gate Valve	<div>0 ▾</div>
Plug Valve	<div>0 ▾</div>
Miscellaneous	<div>1 ▾</div>

Reset

Conclusion & Comments

- In this example, both valves in the Blowoff Assembly were the same size. The downstream valve was chosen as the Blowoff valve because, being the furthest downstream, it would experience the lowest flowing pressures and, therefore, would be the most likely to experience choked flow.
- If additional “Miscellaneous” fittings are required for a specific configuration, any of the unused fitting types can be used to represent the additional fittings. For example, if there were a silencer located downstream of the separator, its Le/D value could be entered for any of the unused “standard” fittings. An appropriate value selected for that fitting type in the *Fittings List*, or the Le/D value for the silencer, could be added to the Le/D value previously calculated for the separator. Or the equivalent lengths could be combined as shown in the next example.

Example 7 - “Equivalent Lengths” To Model Complicated Piping

Background

Some inlet and blowoff piping configurations may not fit into the general purge model. For these cases, it is still possible to accurately model the pressure drop in the piping by using an “equivalent length” of piping that provides the same flow resistance. This was alluded to in the *Comments & Considerations* section in Example 6. Let’s use the Blowoff Vent shown in Example 6 to demonstrate.

The theory is that the sum of the individual resistance coefficients in a series of pipes and fittings is equivalent to the total resistance of the entire assembly. In this example, this relationship can be expressed as:

$$K_{vent} = K_{pipe} + K_{elbows} + K_{separator}$$

Where,

$$K = f_t \left(\frac{Le}{D} \right)$$

And,

K = Resistance Factor

f_t = Fully Turbulent Friction Factor

Le = Equivalent Length, Feet

D = Equivalent Inside Diameter, Inches

If the same fully turbulent friction factor (0.015) is used for all of the components, this relationship can be shown as:

$$\left(\frac{Le}{D} \right)_{vent} = \left(\frac{Le}{D} \right)_{pipe} + \left(\frac{Le}{D} \right)_{elbows} + \left(\frac{Le}{D} \right)_{separator}$$

We know the Le/D values for the elbows (14 each) and the separator (93), let’s calculate the Le/D value for the pipe using the following relationship and an *Inside Diameter* value of 5.761 inches:

$$\left(\frac{Le}{D} \right)_{pipe} = \frac{\sum L_{pipe}}{d / 12} = \frac{(10 + 5 + 10 + 10 + 8)}{(5.761 / 12)} = 89$$

Where,

L_{pipe} = Pipe Lengths, Feet

d = Pipe Inside Diameter, Inches

Finally, calculate the total equivalent length of the vent using the following relationship:

$$\left(\frac{Le}{D}\right)_{vent} = 89 + (3 \times 14) + 93 = 224$$
$$L_{e\ vent} = \left(\frac{Le}{D}\right)_{vent} \times d / 12 = 224 \times 5.761 / 12 = 108$$

This value can now be entered as the Blowoff Vent length, using the common value of 5.762 for the *Inside Diameter* value. Using the $L_{e\ vent}$ value for the “length” of the pipe and selecting zero for the quantity of each fitting will result in the same pressure drop and flow rate as entering the individual values and quantities.

Conclusion & Comments

Although a bit complex and time-consuming, the above method can be used when it is necessary to include a complex system of piping and/or other components that cannot be easily accomplished using the standard pipe and fitting entries.

Example 8 - Clearing

Background

The following example will guide you through the general steps involved in calculating the results associated with a flow-controlled clearing operation. Calculate the time required to clear a pipeline segment containing natural gas, using air supplied from a 185 cfm rated compressor connected by way of 1" rubber hose, using a single 6 foot vent of 1" standard wall steel pipe, with an 1 inch ball valve attached to the Pipeline with a 1 foot riser of 1" standard wall steel pipe, at the following conditions.

1000 Feet - 4-inch 0.237 inch (standard) wall pipe

Inlet Flow Rate = 185 sCfm (11,100 sCfh)

Base Pressure = 14.73 psia

Base Temperature = 60 Fahrenheit

Atmospheric Pressure = 14.73 psia

Flowing Temperature = 60 Fahrenheit

Inlet and Blowoff Efficiency = 0.5

Note...

The example assumes that the pressure in the Pipeline has been lowered to atmospheric pressure (0 Psig) by venting or some other means before the start of the clearing operation.

Data Entry

This example illustrates how to enter data and calculate the results for clearing a Pipeline using a “flow-controlled” air supply. To perform the calculation, complete the following steps:

- Log in to the GASPurge service.
- On the Project step:
 - Click the *Clear* command button.
 - For *Title*, enter **Purge Example**.
 - For *Project ID*, enter **Ex8**.
 - For *By*, enter **Your Name**.
 - For *Date*, type **Today’s Date** in your preferred format.
 - For *Notes*, type **Clearing Example**.
- Click the *Next* command button.

- On the Configuration step:
 - For *Purge Gas*, select **Air**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Purge Gas when the “Air” option is selected.

- For *Pipeline Gas*, select **Typical US Natural Gas**.

Note...

The values for *Specific Gravity* and *Viscosity* will automatically be entered for Pipeline Gas when the “Typical US Natural Gas” option is selected.

- Click the *Next* command button.
- On the Parameters step:
 - For *Control Variable*, select **Flow**.
 - For *Inlet Flow Rate*, enter **11100 sCfh**.
 - For *Base Pressure*, enter **14.73 Psia**.
 - For *Base Temperature*, enter **60 Fahrenheit**.
 - For *Local Atmospheric Pressure*, enter **14.73 Psia**.
 - For *Plot Time Interval*, enter **1 Seconds**.
 - For *Maximum Time Duration*, enter **10 Minutes**.
 - Click the *Next* command button.
- On the Inlet step:
 - For *Inlet Pipe*, select **Yes**.
 - For *Inside Diameter*, enter **1.000 Inches**.
 - For *Wall Roughness*, enter **0.0028 Inches**.
 - For *Length*, enter **20 Feet**.
 - For *Hydraulic Efficiency*, enter **0.5**.

- Click the *Reset* command button beneath the *Inlet Fittings* List.
- For *Inlet Fittings*, select **1** next to the *Ball Valve* item.
- Click the *Next* command button.
- On the Pipeline step:
 - For *Inside Diameter*, click the *Select* command button.
 - On the Pipe Selection page:
 - For *Material Type*, select **Steel**.
 - For *Nominal Size*, select **4**.
 - For *Wall Thickness*, select **0.237**.
 - The *Inside Diameter* value is **4.026 Inches**.
 - Click the *Apply* command button.
 - The *Wall Roughness* value is **0.0007 Inches**. (This value is automatically entered when the “Steel” material type is selected on the Pipe Selection page.)
 - For *Length*, enter **1000 Feet**.
 - For *Hydraulic Efficiency*, enter **1.0**.
 - For *Flowing Temperature*, enter **120 Fahrenheit**.
 - For *Number Of Displacements*, select **2**.
 - For *Number Of Segments*, select **Auto**.
 - Click the *Next* command button.
- On the Riser step:
 - For *Blowoff Riser*, select **Yes**.
 - For *Inside Diameter*, enter **1.065 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **1 Feet**.

- For *Hydraulic Efficiency*, enter **0.5**.
- Click the *Reset* command button beneath the *Riser Fittings* List.
- Click the *Next* command button.
- On the Valve step:
 - For *Blowoff Valve*, select **Yes**.
 - For *Valve Type*, select **Ball**.
 - For *Effective Valve Size*, enter **1 Inches**.
 - Click the *Next* command button.
- On the Vent step:
 - For *Blowoff Vent*, select **Yes**.
 - For *Inside Diameter*, enter **1.065 Inches**.
 - For *Wall Roughness*, enter **0.0007 Inches**.
 - For *Length*, enter **6 Feet**.
 - For *Hydraulic Efficiency*, enter **0.5**.
 - Click the *Reset* command button to clear the *Vent Fittings* values (there should be no Vent Fittings selected).
 - Click the *Next* command button.
- On the Review step:
 - Use the scroll bar to review the entered values.
 - Revise values by selecting the associated step (step) and changing the value.
 - Click the *Calculate* command button to proceed with the calculation.
- On the Results step:
 - Review the calculation results.

- Either save the results, print the results, or edit the calculation input values and calculate again.

Results

The results should be similar to the following:

Arrival Time:	0.65 Minutes
Purge Time:	1.84 Minutes
Mean Velocity:	25.77 Feet/sec
Minimum Interface Velocity:	19.32 Feet/sec
Minimum Allowable Velocity:	2.15 Feet/sec
Mixed Zone Length:	67 Feet
Purge Gas Used:	332 sCf
Minimum Slug Volume:	7 sCf
Natural Gas Vented:	197 (99 is correct value) sCf
Segment Count:	10

BACKGROUND INFORMATION

History

The American Gas Association (AGA) produced a *Purging Principles And Practices* manual to provide “guidelines for maintaining safe atmospheres inside pipes, holders, and other facilities that are to be purged into service or taken out of service”. As part of this effort, AGA desired to have a computer program for calculating gas pipeline purging requirements and conditions. This program (the “Original Software”) was developed around 1996 under the Gas Research Institute (GRI) project GRI-97/0104 *Pipeline Purging Principles And Practices Research*.

Development

In 2018, AGA commissioned the Gas Technology Institute (GTI), formerly GRI, to develop an updated version of the Original Software using contemporary software development technologies. GASPurge is the result of those efforts.

The GRI Final Report (1996) included a step-by-step method for performing the basic calculations used by the Original Software. It was hoped that, following the documentation of the original project, the calculations of the Original Software could be duplicated with a modern interface.

The project documentation proved to be incomplete regarding the information necessary to accurately reproduce the Original Software and its results. No source code for the Original Software was available. The documentation for the Original Software implied that the steps documented in the GRI Final Report may have been “tweaked” in the actual software implementation. As it turned out, most of the specific steps and calculations described in the GRI Final Report were not exactly or faithfully implemented in the actual software algorithms. This became apparent when the documented calculations in the GRI Final Report did not align with the calculated results from the Original Software.

Rather than a step-by-step duplication of the Original Software, the development of GASPurge used the Original Software as a guide for the required functionality and as a benchmark for testing the new calculations. This process required some experimentation and iterative development to approximately match the results of the Original Software.

Although the Original Software will not conveniently run on modern operating systems, it can still be executed on older systems. This allowed the development team to compare the calculation results from GASPurge against those from the Original Software.

No actual operating data was provided or collected during the development of GASPurge.

Calculations

Based on the available information, GASPurge performs calculations similar to, but not identical to, those of the Original Software. Following is the approach that GASPurge uses to produce the calculated results:

Pressure-Flow Modeling

- Similar to the original approach, the “system” used to model the purge process consists of an Inlet Pipe, the Pipeline being purged, and a Blowoff Assembly. The Blowoff Assembly further consists of a blowoff riser, valve, and vent, which are collectively referred to as the Blowoff Riser, Blowoff Valve, and Blowoff Vent. The Inlet Pipe and Blowoff Assembly are not required to perform a calculation.
- The flow and pressure drop along the Inlet Pipe and Blowoff Assembly are calculated using “steady-state” modeling techniques. In other words, the amount of gas entering each of these segments must equal the amount of gas leaving the segment. Due to the relatively short length of these segments, compared to the typical length of the Pipeline being purged, this approach is reasonable and valid for modeling the flow and pressure conditions across them.
- The pressure and flow conditions in the Pipeline are modeled using a “transient” analysis derived from the method described by Wylie and Streeter (Reference 8). It is believed that this method is similar to the one used in the Original Software.
- The Inlet Pipe and Blowoff Assembly provide the boundary conditions for the Pipeline.
- The Colebrook-White pipe flow equation is used to model the pressure-flow relationships in both the steady-state and transient analysis.
- The “fittings” attached to the Inlet Pipe and Blowoff Assembly, including the blowoff valve, are modeled using their equivalent hydraulic length. The value is calculated by multiplying the diameter of the pipe by the L_e/D value of the fitting.
- A “hydraulic efficiency” parameter has been included in GASPurge. The use of this parameter is common in modeling applications. Adjusting the efficiency allows the results of the pipe flow equation to be adjusted or tuned to more closely match results recorded in the field. Recommended efficiencies are between 0.5 and 0.7 (0.6 default) for the Inlet and Blowoff sections, and between 0.8 and 1.2 (1.0 default) for the Pipeline. These values are consistent with experience and the results of some basic testing performed in the past.
- GASPurge models fittings attached to any of the “pipe” sections as hydraulic equivalent lengths of pipe. This method is satisfactory for the steady-state calculations of the Inlet Pipe and Blowoff Assembly sections. However, this method is not appropriate for the transient calculation used for the Pipeline section. For this reason, attachment of fittings to the Pipeline is not allowed.
- The Blowoff Valve is modeled as an equivalent length of pipe.

Mixed Zone

- In GASPurge, the length of the Mixed Zone is calculated based on the formulas shown in Section 2.3 (Gas Dispersion Process) of the GRI Final Report (Reference 6). To more closely match the values reported by the Original Software, the length predicted by these formulas is tripled. This concept (of multiplication) is supported by comments in the original documentation.

Comments & Considerations

- The original intent was to develop the New Software by following the documentation presented in the GRI Final Report (Reference 6). Unfortunately, after reviewing the documentation and the Original Software, it became clear that the documentation does not accurately represent the methods used in the Original Software. In particular, the documentation presents a steady-state calculation method, while the Original Software appears to use a transient calculation method.

- The GRI Final Report (Reference 6) presents a certain method of calculating the “Mixed Zone”; the results of the Original Software do not match the results predicted by this method. As a result, a completely new calculation algorithm was derived based on the clues provided by the original documentation and the Original Software results. The results of the new calculation method are generally within 10% of the Original Software results, with the highest differences occurring for short segments of pipe (less than 10,000 feet). Without detailed sample data, it is not possible to determine which method is actually “correct”.

- Both the GRI Final Report (Reference 6) and the User’s Guide for the Original Software (Reference 7) indicate that the “step-by-step” method described in the GRI Final Report to calculate the Arrival Time is not the method used in the Original Software. A reference is made to Wylie and Streeter; however, no details of the implementation are provided. As a result, a completely new calculation algorithm for the Arrival Time was derived based on the clues provided by the documentation, the Original Software results, and the transient methods described in Wylie and Streeter (Reference 8). The results of the new calculation method are generally within 10% of the results of the Original Software, with the highest differences occurring for shorter pipe segments.

- It is not known what equation the Original Software used to model the flow versus pressure drop in the Pipeline.

- The documentation for the Original Software did not mention a hydraulic efficiency parameter. It is assumed that hydraulic efficiency was not used in the Original Software calculation routine.

- The Original Software modeled the blowoff valve using a different method.

- The pressure, flow, and velocity results of GASPurge compare moderately well with those of the Original Software. There appears to be a discrepancy in the handling of the blowoff section between the New Software and the Original Software. The New Software offers options to select “No Vent”, “No Valve”, and “No Riser” to indicate the absence of all or portions of the Blowoff Assembly. In this case, the purge is calculated as though gas is vented directly out of the end of the Pipeline. The Original Software allowed the User to specify a zero length for the riser and vent sections. However, there was still some resistance to the flow. Evidence of this is that changing the size of the zero-length vent pipe affects the calculation results. Consider this when comparing results for this type of configuration.
- Both the Original Software and the original documentation use a standard wall roughness of 9.6 mils. This value was used when attempting to match results between GASPurge and the Original Software, but it is an unusually high number for modern steel or plastic pipe. The AGA GEOP Distribution System Design Book (Reference 9) lists an average roughness value of 0.7 mils for steel and 0.06 mils for plastic. These are the default values used in GASPurge. If using these values and attempting to match results from the Original Software, the *Hydraulic Efficiency* value of the Pipeline may also need to be adjusted.
- GASPurge handles choked flow on the Inlet and all of the Blowoff sections. It does not check for or handle choked flow in the Pipeline section. This is similar to the Original Software.
- The User’s Guide for the Original Software mentioned that a “reducing tee” was automatically accounted for at the inlet connection. It is not clear what equivalent length value was used for this connection. GASPurge does not assume the inlet connection. When trying to match the results of the Original Software, include a Branch Tee fitting on the Inlet section.
- The User’s Guide for the Original Software mentioned that the inlet piping was ignored when calculating results for a flow-controlled configuration. GASPurge allows for inlet piping under flow-controlled configurations and compensates for choked flow conditions that may occur. When trying to match the results of the Original Software, select “No” for the Inlet Pipe option.
- A “ramp-up” time is used to start the purge calculation. The “ramp-up” time refers to the time to go from zero pressure or flow to the specified control pressure or flow. It is used to simulate the slow opening of the inlet valve. The New Software uses five steps, each lasting 1 second, for the “ramp-up” time. Although it is known that a ramp-up was used in the Original Software, it is not clear how many steps were used and what their increment value was.
- On Pipelines approximately 5000 feet in length or less, the Arrival and Purge times may be achieved before the ramp-up time is completed. This means that the flow or pressure control value will not be reached before the purge process is complete.
- GASPurge uses a single flowing temperature for all piping sections. It is assumed that the flowing temperature has a negligible effect on the results. It is known that the Original Software allowed entry of different flowing temperatures for the Inlet and Pipeline sections. It is unclear how these values were utilized in the original calculations.

- GASPurge “mixes” the gas properties within certain calculation “segments” of the Pipeline. If, during the calculation, a segment of the Pipeline contains both the Purge Gas and the Pipeline Gas, the properties of the “gas” for that segment are proportioned. If, for example, the Pipeline was divided into segments of about 1000 feet each, and if at a certain time step a segment contained 100 feet of the Purge Gas and 900 feet of Pipeline Gas, the gas properties would be calculated as 10% (100/1000) Purge Gas and 90% (900/1000) Pipeline Gas. Using this method helps “smooth out” the calculation results and somewhat approximates the movement of the Mixed Zone down the Pipeline. It is not clear how the Original Software handles mixing within the calculation segments.
- In extreme configurations where the length of the Pipeline is relatively short, and the diameter of the Blowoff Assembly is small compared to the Inlet diameter, GASPurge is unable to calculate a suitable solution to the transient portion of the analysis. For example, 1000 feet of 12-inch Pipeline, filled through a 10-inch inlet, and vented through a 2-inch Blowoff Assembly will not “solve”. Future revisions to the calculation routine may address this issue.
- In configurations where the Arrival Time is long, there is a long contact time at the gas-to-gas interface. This should result in a longer Mixed Zone length compared to similar conditions with a short Arrival Time. The Mixed Zone calculation method used by both the Original Software and GASPurge predicts a shorter Mixed Zone. The very nature of a gas mixture is for the different gases to disperse and eventually become completely “mixed” given enough time. It would therefore seem that longer contact times would result in more gas mixing and therefore a longer Mixed Zone length. It is believed that this is caused by the way that velocity is used in the mixing/diffusion equation. Additional research is required to develop a more suitable mixing method.
- The properties of the inert gas slug were not considered in the GASPurge hydraulic calculations. It is not clear how or if these properties were considered in the Original Software.

Gas Properties

The gas property values (specific gravity and viscosity) associated with the “Typical US Natural Gas” and Hydrogen blend gas types were calculated based on the following base composition:

Average Natural Gas Composition	
Compound	Mole Percent ①
Methane	93.07
Ethane	3.21
Propane	0.59
Higher Hydrocarbons ②	0.32
Non-hydrocarbons ③	2.81
Notes: ① - Assumed to be expressed in mole-percent. The reference did not specify. ② - Modeled as Hexane. ③ - Modeled as other non-contributing compounds. Reference 10	

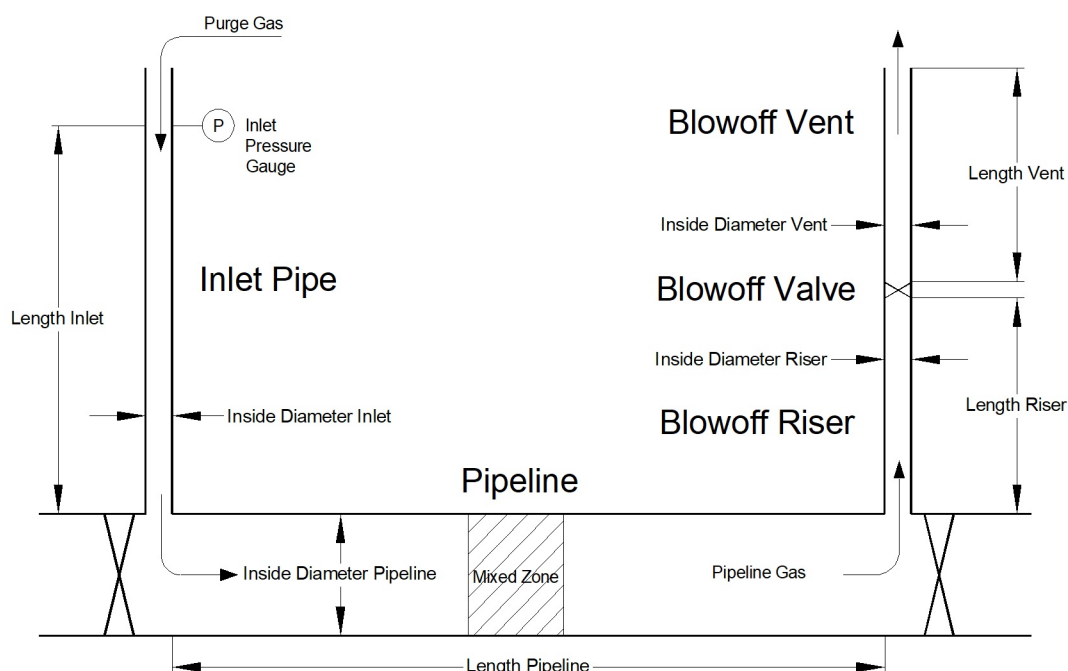
Predefined Gas Property Values		
Gas Type	Specific Gravity	Viscosity, Lbm/Ft-Sec
Typical US Natural Gas	0.567	0.000007
5% H2 / Natural Gas Blend	0.543	0.000007
10% H2 / Natural Gas Blend	0.519	0.000007
15% H2 / Natural Gas Blend	0.495	0.000007
Notes: • The property values were calculated with the B3PE GASCalc™ 6.0 software using a Base Pressure of 14.73 Psia and Base Temperature of 60 Fahrenheit. • The Hydrogen blend types assume that the mole-percent of the Methane component will be reduced by the indicated percent Hydrogen. And that the indicated percentage of Hydrogen will be added to the composition.		

The gas property values for the Air and Nitrogen gas types were calculated using the B3PE GASCalc™ 6.0 software, with a Base Pressure of 14.73 Psia and a Base Temperature of 60 Fahrenheit, assuming a 100% composition of the indicated component.

GLOSSARY

Glossary

Figure 14 - Model parameters and components.



Arrival Time - The time required for the gas-to-gas interface to reach the end of the Pipeline (the point where the Pipeline is connected to the Blowoff Assembly).

Blowoff Assembly - Refers to the components (Blowoff Riser, Blowoff Valve, and Blowoff Vent) through which gas exits the Pipeline.

Blowoff Riser - The portion of the Blowoff Assembly that is directly attached to the Pipeline being purged, and immediately upstream of the Blowoff Valve.

Blowoff Valve - The valve (if any) installed in the Blowoff Assembly. For the calculations performed by the Service, it is assumed that the Blowoff Valve is located immediately downstream of the riser and immediately upstream of the vent. This valve is handled in the calculation separately from any valves attached as fittings.

Blowoff Vent - The portion of the Blowoff Assembly immediately downstream of the valve. This is the last pipe segment that the gas passes through before being released into the atmosphere.

Fitting - A non-pipe component attached to a segment of pipe. Elbows, tees, and valves installed along a pipe are examples of a fitting.

Hydraulic Efficiency - A practical term used to adjust or tune calculated values to better match field data.

Inlet - The portion of the pipe through which gas is introduced into the Pipeline.

Le/D - As used in this documentation, a value equal to the equivalent length of a fitting divided by the Inside Diameter of the fitting. For the calculations performed by the Service, the Inside Diameter of a fitting is assumed to be equal to the Inside Diameter of the pipe to which it is attached.

Mixed Zone - The length of the region within the Pipeline that may contain a mixture of Purge Gas and Pipeline Gas.

Pipeline - The portion of pipe to be purged.

Pipeline Gas - The gas in the Pipeline before the purge operation. The gas to be displaced

Purge Gas - The gas introduced into the Pipeline during the purge operation. The gas used to displace the Pipeline Gas.

Purge Time - The total time required to complete the purge operation. For the results produced by the Service, it is defined as the Arrival Time, plus the time required for one-half the Mixed Zone to reach the end of the Pipeline, plus the time required for any additional displacements to reach the end of the Pipeline.

Roughness - A value representing the effective roughness of the inside pipe wall.

Slug - An inert gas injected into the Pipeline directly ahead of the Purge Gas. The purpose of an inert slug is to separate the Purge Gas and Pipeline Gas.

REFERENCES

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